College of Engineering and Physical Sciences

School of Informatics & Digital Engineering, Computer Science

Final Report

Title: Web Product Comparison System

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Module: CS3IP

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April 24th 2023

Declaration of Originality

I declare that I have personally prepared this assignment. The work is my own, carried out personally by me unless otherwise stated and has not been generated using paid for assessment writing services or Artificial Intelligence tools unless specified as a clearly stated approved component of the assessment brief. All sources of information, including quotations, are acknowledged by means of the appropriate citations and references. I declare that this work has not gained credit previously for another module at this or another University, save for permitted elements which formed part of an associated proposal linked directly to this submission.

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Acknowledgements

I would like to thank my supervisor, Megan Robertson, for her brilliant recommendations and continued support throughout the year while working on the project.

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Section 1: Introduction

1.1. Abstract

In today's society, online shopping and the uproar in the usage of mobile technology for e-commerce have grown in popularity as a result of the high rise in consumer technology sales in modern culture. This report will cover the procedures taken to produce a system for delivering the cheapest products and making recommendations to satisfy consumers' demand for an extensive platform that offers details on technology products. It will take advantage of household technologies such as cell phones and laptops. The system offers product comparisons, descriptions, ratings, and recommendations based on user preferences. It will appeal to younger, tech-savvy audiences who prefer online and mobile shopping.

1.2. Project Stages

This project will follow the following stages:

Section 1: Introduction

A brief of what the project contains and the outcomes of the project. It also hasa breakdown of how the project will flow.

Section 2: Background Research

a. 2.1. – 2.4. The Introduction will introduce the focus and aim of the project, explaining the purpose of the project, the application which will be developed, and the research topics.
b. 2.5. A short Literature Review will be conducted to take a look at related and any relevant existing technologies applicable to my design.
c. 2.6. System requirements will be used as it's necessary when developing a software - as requirement delving into and the priorities of the software, leads to robust systems.

Section 3: Project Management

d. 3.2. Development methods: a comparison of different types of methodologies used to develops software effectively.
e. 3.3. Project timeline: Detailed breakdown of where effort will be placed at each point in the project lifecycle.
f. 3.4. Risk Assessment. This section will cover the risks associated with the software and potential mitigations.

Section 4: Implementation

g. 4.1. System Design is important to discuss as there can be multiple ways for the system to take shape in but picking the most suitable one is vital.
h. Sections 4.2 – 4.6 cover use case diagram, activity diagrams, system architecture, webpage and database design, choices of programming languages and the technical implementation of the back end.

Section 5: Evaluation

i. System Testing. It is vital to test the systems functionality to check it meets all its requirements.

j. Project Evaluation. This section will contain the Project Evaluation as it is important to assess if the aims set out in the initial stages of the project have been met.
k. Further developments. This section will focus on the further developments which will be identified through various means of testing and research to improve the final product.

Section 6: Conclusion

l. A reflection of the whole project focusing of achievement and learning opportunities.

Section 2: Background Research

2.1. Introduction

The rise of online shopping and mobile technology for making purchases has become increasingly prevalent due to the importance of consumer technology in contemporary society. Consequently, developing a system that is both engaging and easy to navigate is essential to cater to the needs of modern consumers. Younger, tech-savvy customers who favour mobile and internet buying will be drawn to the system.

Subsequently, the system offers users the function to be able to see a product type, details, and reviews of a product which is situated on a different site. It can also recommend products based on the product a user is viewing.

The system will abide by "performance expectancy, effort expectancy, social influence, and facilitating conditions", which are the four direct determinants of user acceptance and usage behaviour (Gasparic and Janes, 2015). By using the latest available techniques like web scraping, the system will be created to be user-friendly due to the flexibility of techniques such as this.

The user will be given a choice to register and log on to the system to create accounts and have their data preserved securely which will require providing an email address or a username and password. Within the system, a user's guide page, contacts, categories, user settings, and a favourites area (for users to save items) will all be present on the home screen along with system information. The categories offered will allow users to conduct product searches. As users join up, the system will also offer user settings and the option to view their favourites.

2.2. Project Motivation

The main project motivator is the need to help consumers save money and make better informed purchase decisions. Many shoppers look for reliable review sites or comments alike to determine where the cheapest places are to buy a product that is also reliable. Therefore, the need for a website that provides users with the cheapest place to buy a product, customer reviews, and product details all in one place is a gap in the market.

By creating a platform that is secure and user-friendly, users can be confident that their personal information and payment details will be safe while they browse and shop for products. Additionally, the website's focus on affordability and accessibility which are values desirable by consumers looking to make informed purchase decisions without breaking the bank.

2.3. Aims and Objectives

Considering SMART targets when setting aim for a system of this scale is important so that the best quality product can be delivered. To begin, the website should be user-friendly and secure, providing customers with the cheapest place to buy a product. It should also allow users to see other customer reviews and the details of the product. The following objectives have been set to achieve this aim:

- Research into the most common practices for web development, security measures, and user experience design. This will in turn create a user-friendly website that prioritises the security of the data given by the users.
- The website will be capable of displaying the product details, customer reviews, prices, and the cheapest place to buy a product clearly.
- Customer confidential details such as emails and passwords will be encapsulated by effective security controls such as encryption to protect user data from potential security threats.

- Functionality of the website will be tested so that user feedback for further improvements can be obtained.
- Analyse user feedback and make necessary changes to the website to improve the user experience and security measures.

The success of this project will be evaluated based on the following criteria:

- The website must be fully functioning, ready to provide product details, customer reviews, and the best price for a product.
- To guarantee that user data is protected from potential security threats, security controls must be applied successfully.
- The website must be simple to use and offer customers a satisfying browsing experience.
- To find areas for improvement and make the necessary changes, user feedback must be gathered and analysed.
- The website will give users a useful service, enhance their online purchasing experience, and put their security and privacy first by achieving these goals and satisfying the success criteria.

2.4. Background Research

Recommendation systems have been identified as a growth area as they and site referrals websites are becoming increasingly popular in the business sector. These systems collect data on users' purchases, web browsing activity and search queries, to provide tailored recommendations and suggestions relevant to each individual. This helps businesses and organisations boost sales and engagement by displaying items and services that are more likely to be of interest. The use of these systems has become a crucial part of e-commerce and is expected to continue growing in the future.

2.4.1. Importance of a consumer technology recommendation system

An online system capable of making recommendation is important because it will higher user engagement compared to traditional methods, as studies have found that “the use of online shopping is rapidly increasing and purchases by mobile phones are expected to reach 31 billion by 2016” (Jen-Hui Wang et al., 2015). The versatility of online shopping services supported by widespread mobile technology appeals to consumers (Puster et al., 2012). Therefore, it is important to put the recommendation system in the most accessible location possible as it stimulates user engagement. Moreover, the system manages technology, attracting younger and technology-fluent audiences that are shown to prefer mobile and online shopping – which this recommendation system adheres to.

There are four factors that are important which directly influence if the user approves and also their usage behaviour. (Gasparic and Janes, 2015) The first is “performance expectancy, which measures how much a person thinks utilising the system will enable them to complete a task more effectively.” The second factor is “effort expectancy”, which deals with how simple using the system is. The third factor is “social influence, which measures how strongly a person believes that influential people think they should use the new system. The degree to which a person feels that an organisational and technological infrastructure exists to facilitate the use of the system is the final component of facilitating conditions.”

2.4.2. Growth of recommendation systems in business

Due to recommendation systems and site referral systems increasing in popularity, client behaviour has become more understandable hence why they are growing in popularity in the corporate world. These systems can offer individualised recommendations and suggestions by gathering information on users' purchases, web browsing activities, and search queries. By showcasing goods and services that are more likely to be of interest, this aids companies and organisations in increasing sales and engagement. Also, by offering a more individualised and user-friendly experience, the adoption of these solutions contributes to improving customer service.

2.4.3. Growth of technology in society

The rate of growth in technological usage in today's society has been greatly influenced by the digitalisation of conventional services such as shopping as well as technology's increasing accessibility due to how in demand devices like mobile phones are. With developments in areas like, machine learning and the internet of things, there is a rising need for cutting-edge technology that can perform tasks that people find tedious and do not want to do themselves. This spike in growth has the potential to drastically change many industries (particularly that of e-commerce) as well as how we live and work in the future, whether for the better or worse in the long term.

2.5. Literature Review

2.5.1. Introduction

This section will examine the significance of price comparison and product recommendation websites. In the age of internet shopping, to know what customers want in terms of functionality and personal preferences, it will be necessary to examine multiple similar websites that are readily available for use keeping in mind the most well-liked ones. The important factors will be the security measures put in place by these systems to protect user information and uphold privacy, as well as their marketing strategies used to attract and retain users. The project's goals and objectives as well as an assessment of similar website's effectiveness will be informed by the research findings from this area of the report.

Recommendation scripts are used by many popular e-commerce websites, like Amazon, to offer consumers customised product recommendations based on their prior purchases and browsing activities. Similarly, numerous social media sites like Facebook and Instagram notoriously employ recommendation systems to recommend goods based on how users have interacted with adverts and sponsored content in the past. Furthermore, there are many discrete product recommendation websites that provide customers with tailored product recommendations based on their past purchases, browsing histories, and search queries which may be used if a user consents to it.

2.5.2. Popular price comparison sites

Price comparison websites are more common among shoppers in the age of internet purchases as customers often want to compare prices easily and quickly between different stores. This opens an avenue to save money by buying the cheapest version.

The websites that will be looked at in this section each have a unique selling point by using a range of user attraction and retention techniques. To begin, an extensive database of products and services is needed such as that found on the websites like ‘PriceRunner’ " (which boasts an extensive database of electronics, clothing, and home furnishings). On the other hand, "Google Shopping" takes advantage of its status as the most popular search engine and displays relevant product results and pricing from other retailers. Sites like ‘PriceRunner’ focuses on providing accurate and up-to-date pricing information, while other popular services such as Amazon, uses its vast selection of products, offers both its own and third-party products. ‘CamelCamelCamel’ is another example of a site which is popular due to its unique price alert feature - helping users to track the price of products and receive notifications when the price changes.

There are many marketing techniques used by these sites including search engine optimisation, social media advertising, and email marketing campaigns. It is also common to offer incentives such as cashback or promo codes to persuade consumers to use their services over their rivals.

The following sections will delve deeper into ‘Google Shopping’ and ‘PriceRunner’ as they are excellent price comparison platforms and analyse their features to determine what makes them successful.

2.5.3. Google Shopping

Usually, when a consumer wants to find out the price of a product that crosses their mind, Google Shopping is often the first price comparison platform they come across unintentionally. The software has been around for a while originally being introduced by Google in 2002, but not catching on until 2012 when it transitioned into a paid advertising model. Google Shopping as a product search engine allows for seamless comparisons in prices and items from multiple retailers. This is what separates it from its competition as it is integrated into the Google Search engine.

Various research studies have delved into the features that contribute to Google Shopping's success. One standout characteristic is its capacity to present relevant search outcomes from multiple retailers. By leveraging Google's search engine algorithms, “the website showcases the most relevant products and prices, simplifying the user's search process” (K. Blanckenburg, 2018). This feature proves especially valuable for individuals seeking specific products, as it facilitates swift comparisons of prices and attributes from different retailers.

Another feature of Google Shopping is that it provides users with easy access to products information they are looking for (K. Blanckenburg, 2018). This includes data such as the product image, description, and prices. This feature allows for seamless comparison – therefore, setting it apart from its competitors as users are able to quickly evaluate different options. As a result, users are more likely to buy a product from their platform.

Furthermore, Google has an extensive database which is linked to Google Shopping. This database is used to provide users with data about the products they search for. Additionally, users are able to obtain reviews on products left by other users which they can use to help them make decisions.

Google also has a dominant stance in the search engine industry meaning it is capable of generating a large quantity of traffic for its e-commerce site. This factor alone would likely attract not just users but also sellers to post their items up for sale on Google Shopping.

Another aspect of Google Shopping's popularity is its "Price Tracking" tool. This function enables users to specify a target price for a product and be alerted through an automated email when the price drops below what the user wants. This feature, according to studies from V. Victor, boosts user loyalty and engagement as consumers become more aware of price fluctuations, they tend to be more strategic and their loyalty towards the high seller weakens and vice versa (V. Victor et al., 2018).

2.5.4. PriceRunner

This section is based on primary research conducted on the ‘PriceRunner’ website and all opinions are based on findings from the research. The success of PriceRunner can be attributed to its user-friendly platform, a broad range of goods and services for selection, a significant market presence, and its customer contact elements. To begin, the main elements that contribute to PriceRunner's success is down to its usability. Things that contribute to its usability is the ability for users to filter search results by brand, price, and other categories through its search bar placed on the homepage. Also, as well as PriceRunner being a website, it also has a mobile application which allows its users to easily compare costs while on the go and the fact that it's an app gives it the ability to send notifications to its user's mobile devices.

PriceRunner also boasts an extensive database of products and services such as notifications of price drops, personalised recommendations, and shopping guides to help users make choices while shopping on their site. This makes PriceRunner versatile which may be a defining factor in it attracting and retaining customers. In terms of its large database, PriceRunner doesn't just cover one category but ranges over many sectors, including electronics, clothing, and home goods.

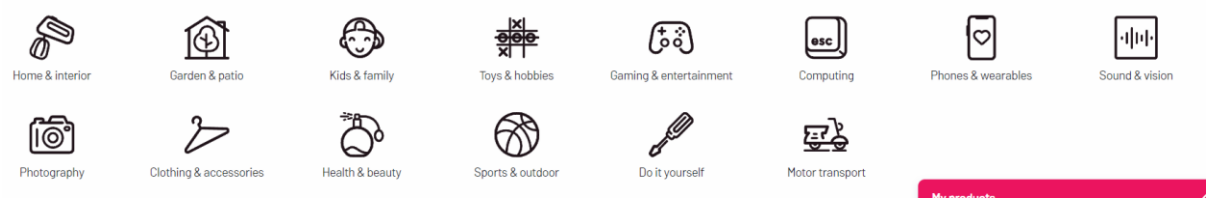


Figure 1: price runner categories

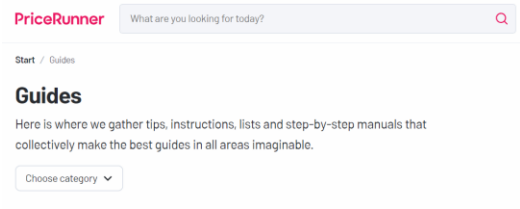


Figure 2: Price Runner Guide

Finally, customers can get in touch with PriceRunner through a variety of channels, including email, social media, and a website feedback section. Users can utilise this to voice their ideas, ask questions, and offer feedback to retailers and other consumers. In an effort to maintain an open line of communication with its users, PriceRunner routinely often details its pricing policy and data-gathering practices. PriceRunner also upholds its transparency by listing who works in each department and a brief background on them on their website in the about us section. This dedication to transparency and responsiveness to user feedback may have a positive impact on the platform's users' rising trust and loyalty.

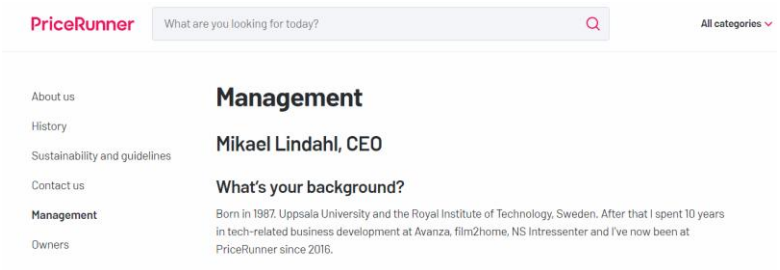


Figure 3: price runner feedback

2.5.5. Findings

The examination of Google Shopping and PriceRunner as two excellent price comparison websites has shed light on the characteristics that make them successful. Both systems are well-liked by customers for allowing them to compare prices and items from multiple stores thanks to their distinctive features.

The combination of the Google Search engine with Google Shopping, a well-known platform, benefits users by making it easy to search and compare products. The website shows relevant products and prices by utilising Google's search engine algorithms, further improving the user's search experience (K. Blanckenburg, 2018). Moreover, Google Shopping provides instant access to product details including photographs, descriptions, and prices, facilitating customer comparison shopping, and eventually boosting sales. The platform draws consumers and retailers alike because of its big database and outreach - as it is in a leading position in the search engine market. Furthermore, the "Price Monitoring function increases user engagement and loyalty by enabling users to track price changes and plan their purchases" appropriately (V. Victor et al., 2018).

Contrarily, PriceRunner credits its user-friendly platform, substantial product database, and consumer engagement tools for its success. The website's search tool lets users narrow down results by brand, cost, and other criteria, and its mobile application lets users compare prices while they're on the road and receive customised alerts. Electronics, apparel, and home items are just a few of the several categories included in PriceRunner's database, making it a flexible platform for users. To help consumers make wise decisions, the platform also provides shopping advice, tailored recommendations, and price decrease notifications.

Also, PriceRunner allow open dialogue with its customers through a variety of channels, including email, social media, and a website feedback section, which makes it easier for consumers to share ideas, ask questions, and provide feedback. Additionally, the platform routinely makes details about its pricing scheme and data collection methods available, encouraging openness and user confidence. PriceRunner further demonstrates its dedication to transparency by disclosing its staff members and their backgrounds on the website, which is seen to have a beneficial impact on users' confidence and loyalty.

2.6. System Requirements From User based Research

2.6.1. Introduction

The functional and non-functional requirements for the system are developed in this section using the research on similar websites from Section 2.5: Literature Review, and the user-based secondary research conducted in this section.

2.6.2. Secondary Research

Due to the significance of User Interface (UI) and User Experience (UX) in E-Commerce and the quick advancement of technology, UI is now a “crucial consideration when building websites or applications”, especially for platforms used for E-Commerce (Gunawan et al., 2021: Section I). “The UI directly influences customers' purchasing intents as the first point of contact”, highlighting the requirement for an understandable and aesthetically pleasing design (Gunawan et al., 2021: Section II.B). The importance of UX in E-Commerce is also emphasised since it can “increase customer satisfaction and profitability” while also focusing on the vital role that users play in generating revenue for E-Commerce platforms (Gunawan et al., 2021: Section I and II.C).

The key variables that should be taken into account during the design and development process in order to produce a user-friendly website that successfully tackles UI/UX and functionality concerns are:

Table 1: UI/UX success criteria

Variable	Reason
Visual appeal	The website should have an appealing design that draws visitors in and entices them to stay and browse around. A unified and professional appearance will be created by using consistent branding, colour schemes, and typography.
Simple navigation	Users should find the information they're looking for quickly and simply with a well-structured website that has distinct headings and categories.
Responsiveness	Users should have a seamless surfing experience on any device if the website is responsive across different devices and screen sizes.
Accessibility	This concerns users with disabilities and ensuring they will be able to use the site with ease. Features like alternative text for photos, and proper colour contrast are considered.
Personalisation	Personalised online experiences that take into account user preferences and browsing patterns can increase user engagement and boost conversion rates.
User feedback	By encouraging and incorporating user feedback, the website may continue to satisfy users' changing demands while also identifying areas for improvement.
Security and trust	By showing trust badges and maintaining openness in data handling procedures, user confidence will be boosted.

Furthermore, to focus more on improving UX further, emphasising a “solid architecture and interface for the web applications is vital”. This can be done by making the website aesthetically pleasing through “precise layout strategies”, which further improve UX (Gunawan et al., 2021:

Section IV). Additionally, the idea that user-friendliness should be prioritised in all UI/UX designs is paramount to ensure that "users enjoy engaging with the platform and emphasises the importance of gathering user feedback to improve the quality of UI/UX design" (Gunawan et al., 2021: Section IV).

Some further elements which should be considered while building a user-friendly website with regard to UX and functionality in addition to the those previously mentioned are:

Table 2: UX functionality criteria

Variable	Reason
Consistency	Keep the website's design components, user interactions, and functionality consistent throughout.
Error prevention and recovery	The website should be created to reduce user error potential and to provide clear error warnings when problems do occur.
Making effective use of white space	Users should have a seamless surfing experience on any device if the website is responsive across different devices and screen sizes.
Cross-browser compatibility	As users may access the site using a variety of devices and browser setups, make sure the website works correctly and appears the same across browsers.

E-Commerce companies can build a more user-friendly website with an emphasis on UI/UX and functionality by taking these additional variables into account, which will ultimately result in higher customer satisfaction.

2.6.3. System Requirements

The specifications for the comparison system are described in this section separated into Functional and Non-functional requirements where the Functional requirements will describe what is expected of the system in terms of functionality, and the non-functional requirements are used to monitor the system's usability and will be used as a criterion for measuring the success of the system from a front-end view. The priority level given to each requirement will dictate the order which it is implemented.

Functional Requirements

ID	Name	Description	Priority
1.1	Register/Login	The website must give the users an option to register to the system. Users must be able to log out. Users must be able to delete their account. Users' login details must be added to the database once registered.	Essential
1.2	Comparison feature	The website must allow users to compare two products side.	Essential
1.3	Recommendation engine	The website should have a recommendation system to suggests products to users based on the product they are viewing.	High
1.4	Filtering and sorting	The website must allow users to filter and sort search results based on different attributes, such as price, ratings and reviews.	Essential
1.5	User reviews and ratings	The majority of products with available reviews and ratings should be visible to users.	High
1.6	Favourites	The website must allow users to add products to their favourites for later reference.	Essential
1.7	Accessibility	The website should have accessibility features to support disabled users	Low

Table 3: Functional Requirements

Non-Functional Requirements

ID	Name	Description	Priority
2.1	Performance	The website must have fast response times and retrieve data efficiently.	Essential
2.2	Scalability	The website must be able to accommodate increasing numbers of users and products added to the database.	Essential
2.3	Security	The websites database must hash the user's login information for safe encryption.	Essential
2.4	Compatibility	The website should work well with different browsers and devices including mobile.	High
2.5	Responsiveness	The website should adjust to resizing or different screen sizes.	High
2.6	Aesthetic	The website should be appealing and follow the latest design conventions.	Low

Table 4: Non-Functional Requirements

Section 3: Project Management

3.1. Introduction

In this section, the planning and implementation methods will be covered. This will include software development methodologies chosen to support the design, time management tables to explain where effort will go and when, and the methods of implementation used for both the website and the database.

3.2. Development Methodologies

Various software development methodologies dictate the order and iterations of each phase in the software development lifecycle. Traditional methodologies, like the waterfall model, strictly adhere to the order of the lifecycle, making sure one phase is completed one at a time before moving to the next phase. However, there are more flexible methods such as the agile software development method, where the process is iterative (Sinha et al., 2021, section I) and the differences will be discussed in this section.

3.2.1. Waterfall

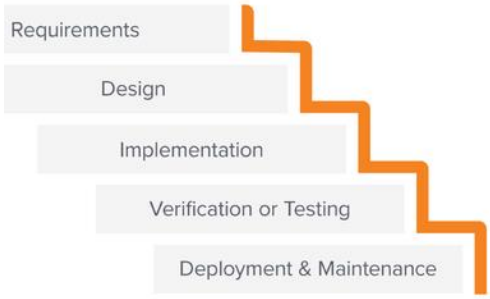


Figure 4: waterfall

"The Waterfall Model is the most traditional and most used to develop software" (Sinha et al., 2021). It progresses sequentially through each stage of the Software Development Lifecycle, with each stage being checked before advancing to the next (Sinha et al., 2021, section II). Although the Waterfall Model is relatively easy to understand, it is "highly restrictive and often not ideal for prototypes or projects with changing requirements during development" (Sinha et al., 2021, section IV.A).

3.2.2. Agile

In contrast, "agile methodologies are consistent with the Agile Manifesto's values and principles for software development, offering more flexibility and adaptability" (Sinha et al., 2021, section III). Agile testing involves the participation of all members of the project team, including specific experts and testers, and is conducted in every iteration, making the process more dynamic and responsive to changing requirements (Sinha et al., 2021, section IV.B).

3.2.3. Extreme Programming

Extreme Programming is a variation of agile software development as the approach increases the development speed, quality, and adaptability of software especially when a client changes their requirements often. Like other agile practices, Extreme Programming is excellent for projects requiring multiple releases due to its lightweight nature compared to the traditional Waterfall Model.

3.2.4. Iterative Model

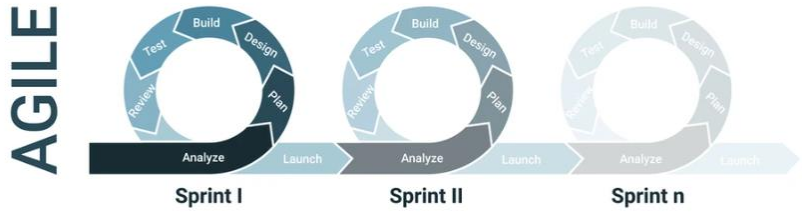


Figure 5: Iterative Model

The iterative model is an approach that involves breaking down a project into smaller manageable sub sections which can be developed iteratively. As a project progresses, the initial requirements set at the start can be refined to make a better system. For example, a way this method can be used effectively is to implement the most basic and fundamental functionalities needed for a system to run, have it tested, reviewed, and then improved. New requirements or features added are based on the results of the testing to further improve performance to satisfy the desired criteria.

This approach to development allows for flexibility and adaptability in a changing development environment. Dynamic environments are often caused by vaguely defined initial requirements which this project will have as the project scope is large – meaning not every possible feature can be conceived at the initial stages. Furthermore, the Iterative Model comes with several advantages one being, a working model can be achieved early on, meaning that the system can be tested and improved over time – resulting in a well-designed system with little to no flaws. By employing this methodology, a balance can be struck between structure and adaptability to ultimately lead a to more successful software.

3.2.5. Chosen Method

For this project, the Iterative Model, which is an agile method has been chosen, as it will be the most suitable software development methodology for a product comparison site because most of the requirements that have been identified in Section 2.6 change the type of environment that the project is being developed in from disorganised to organised. Therefore, the need for adapting to changing requirements is not needed. Nevertheless, as the project progresses, it is likely that problems may lead to more requirements being added to fix bugs which develop or plug holes that were missed in the initial design. Because of this, the waterfall model may become unsuited for the project if revisiting earlier stages due to changing requirements occurs.

Furthermore, methods such as Extreme Programming offer a lot of flexibility but the need for multiple releases isn't a priority for this project as it will be developed continuously for a single deadline. The complications which could arise from employing Extreme Programming are that it could possibly complicate the development process, increase the project's workload, and reduce the quality of the work as deadlines must be met quickly and often. In contrast, the Iterative Model is a straightforward approach, striking an optimal balance between both extremes of software development methodologies.

3.3. Project Timeline

ID	Task	Duration (weeks)	Dependencies
A	Project Definition	2	-
B	Background Research	3	Project Definition
C	Project Deliverables	1	Background Research
D	Literature Review	4	Background Research
E	Secondary Research on UI/UX	2	Literature Review
F	System Requirements	2	Secondary Research on UI/UX
G	System Design	2	Secondary Research on UI/UX
H	Risk Assessment	2	System Design
I	Planning	4	Project definition, project deliverables
J	Implementation	11	Planning, system requirement, System design, Risk assessment
K	Testing	2	Implementation
L	Submission	1	Implementation, Testing

Table 5: Critical Path Table

The critical path is A-B-D-E-F-G-H-I-J-K-L.

Shortest duration: A (2) + B (3) + D (4) + E (2) + F (2) + G (2) + H (2) + I (4) + J (11) + K (2) + L (1) = 35 weeks

As the critical path is also the longest duration, the longest duration is the same as the shortest duration, which is 35 weeks.

Reference Appendix A to see full project plan as a Gantt Chart.

3.4. Risk Assessment and Control

3.4.1. Introduction

It is critical to address any security issues for a project especially that of which will handle sensitive data, including users' personal information and user preferences. As a result, it is crucial to identify potential risks to the system, assess the possibility of these threat's risks materialising, and determine the potential effects they may carry. This section will identify those risks and propose methods to counteract them.

To perform a risk assessment the following steps are taken. Identify the risk, assess risks, control risks, monitor & review and communicate and consult. However, in this section, the focus will be on risk identification, risk assessment and risk control as they are the steps relevant to the safety of the web comparison system.

3.4.2. Risk Identification & Assessment

The following table will identify the risk, describe it, state its likelihood of happening and its impact. The ratings will be based off a probability impact matrix as shown below in figure 6.

(This matrix was taken from "Software Project Management Unit 4: Risk management", Aston University Lecture Slide, page 31)

Figure 6 Probability Impact Matrix

ID	Risk Description	Likelihood	Impact
1.1	SQL injection through login/registration form to access database.	High	High
1.2	Potential of phishing link scams replacing product links.	Medium	High
1.3	Malware attacks such as trojan horse virus.	High	High
1.4	Third party attacks: potential of a third-party site being hacked and indirectly misleading users.	Low	Medium
1.5	Data corruption: software errors leading to inaccurate data being displayed.	Medium	High
1.6	Legal and regulatory issues: Failure to follow data protection laws lead to potential fines and reputation damage.	Low	High
1.7	Technical issues: potential for a host server downtime leading to a crash	Medium	High

Table 6: Risk Identification

3.4.3. Risk Control

For the given risks in the previous section, risk controls will be detailed for each one. The five ways to control risks are as followed:

1. Risk Transfer: This is when the risk is assigned to another entity more capable of dealing with the risk.

2. Risk Mitigation: This is when actions are taken to reduce the impact of a risk that occurs.

3. Risk Acceptance: This is when a risk is accepted if it has less damage than the cost of avoidance.

4. Risk Avoidance: This is when actions are taken to prevent the cause of a potential risk.

5. Risk Reduction: Methods used to reduce the probability of a risk occurring (e.g prototyping).

ID	ID Name	Risk Control Measure	Description
1.1	SQL injection	Risk Avoidance	Perform validation checks on server side and client side on login/register form. Implement scripts to prevent an SQL injection and hash data to keep it encrypted.
1.2	Phishing scam	Risk Avoidance	Implement SSL certificate to encrypt user to browser communications.
1.3	Malware attack	Risk Avoidance	Host the website on a secure hosting provider that provides DDoS protection

			and a firewall. Also encourage users to use strong passwords with special characters.
1.4	Third-party attack	Risk Mitigation	When a product linking to a site that is under attack is reported, the product will be taken off the database for the time being to mitigate the damage to the websites reputation.
1.5	Data corruption	Risk Reduction	Following standard practices such as using correct datatypes for columns will uphold integrity. Also, using constraints and indexes to ensure data consistency and improve performance.
1.6	Legal issues	Risk Avoidance	Obtain user consent to storing their information, complying with data protection laws, encrypting user data, and staying aware of copyright infringement.
1.7	Technical issues	Risk Transfer	Contacting the hosting provider through customer support and describing the issue to them. Following suggested troubleshooting guides provided by the provider and notifying users of the website what the issue is that reassuring them it is being worked on.

Table 7: Risk Controls

Section 4: Implementation

4.1. System Design

In this section of the report, the system design aspects of the price comparison and recommendation platform will be delved into. The various design elements and their significance in achieving the desired functionality and performance of the platform will be discussed.

4.1.1. Use-case Diagram

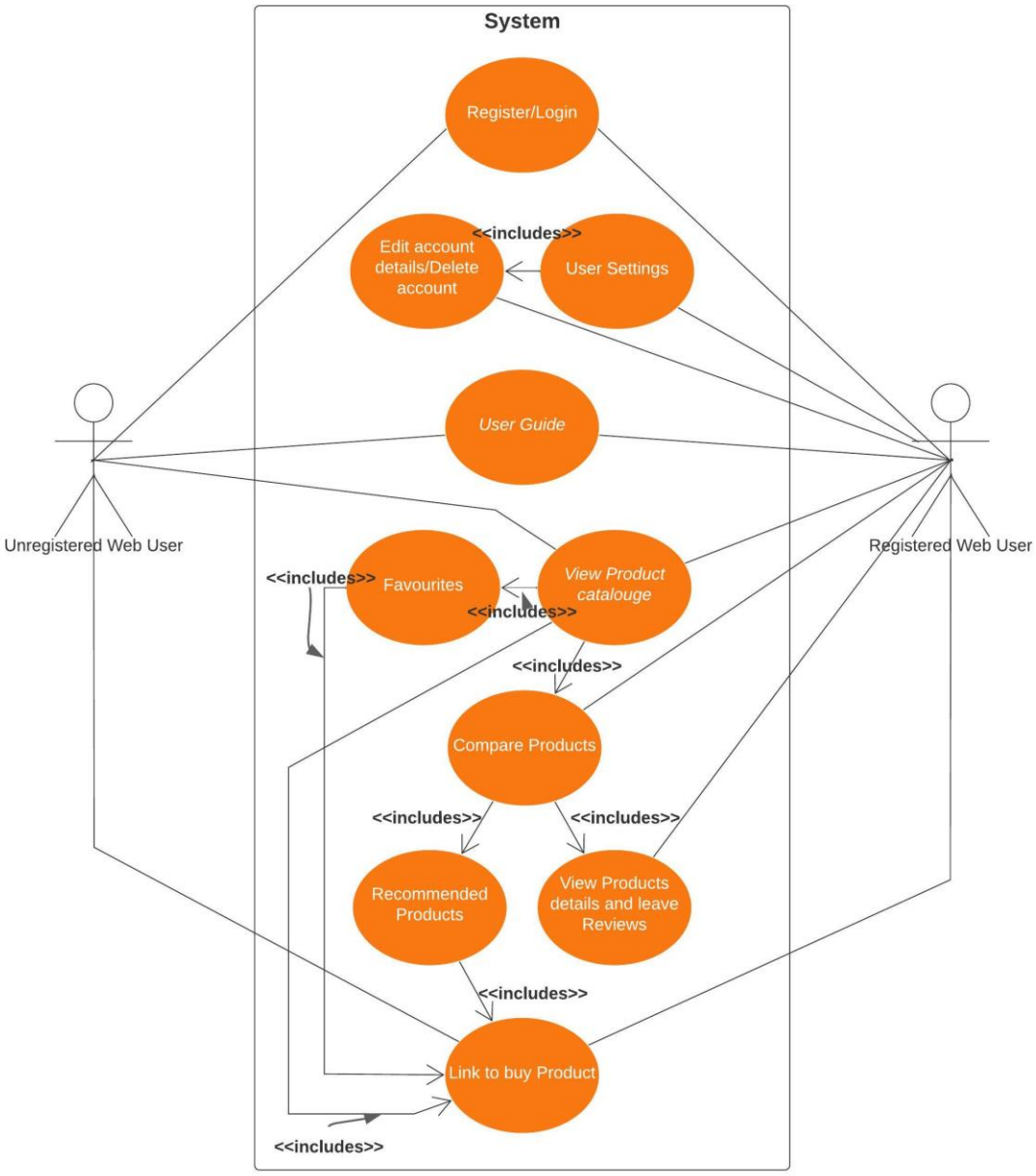


Figure 7 Use Case Diagram

Figure 7 shows how all possible actors can interact with each part of the system. Registered users have access to the entire system while unregistered users are limited.

4.1.2. Activity Diagrams

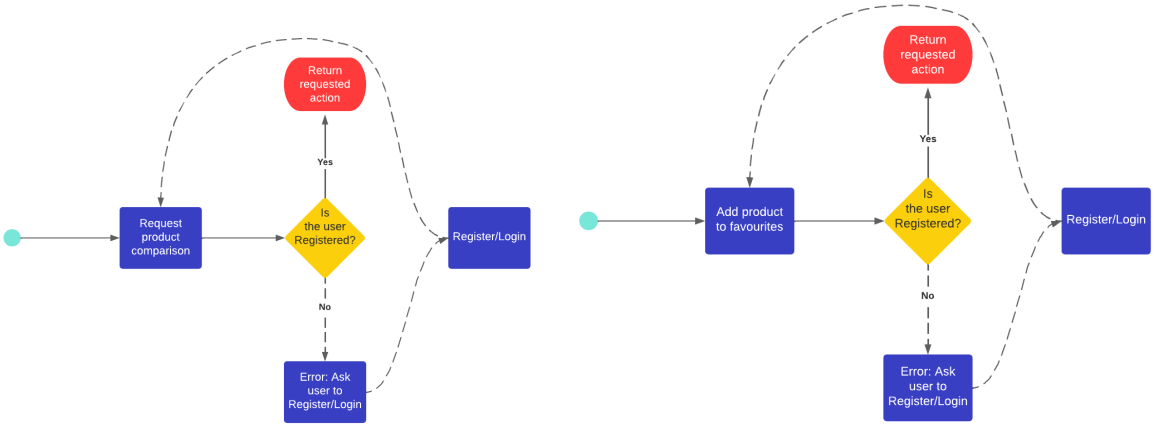


Figure 8: Comparison and Favourites Activity Diagrams

Above are two activity diagrams depicting how a couple of the tasks shown in Figure 7 will work. For a product to be compared or a product to be added to the favourites section, the user must be registered. All tasks will be looked at like this, so all necessary checks are performed before an action is allowed on the site.

4.2. System Architecture

Figures 4 and 5 show that users should be able to access numerous capabilities, such as product viewing, reviewing products, and adding goods to their favourites. This suggests that interactions should be held up using a client-side and server-side server. The user interface will be given by the client side. As for the server side, microservices architecture is the most relevant implementation as each microservice supports a particular system function. For example, user authentication, and search functionalities.

Using software like Laravel, a RESTful API can be used to create communication between the client-side and server-side. This will make it easier to integrate with web apps and mobile for possible further development.

4.3. Webpage Design

In line with the secondary research from section 2.6: Secondary research, the initial design shown in figure 9 below for the User Interface is simple to navigate as every button is clearly labelled, makes good use of effective white space to draw attention towards certain areas and to also help people with disabilities such as dyslexia. Furthermore, the website is responsive as it adjusts to a mobile phone aspect ratio with no issues. As the project moves into the implementation stages, other factors such as visual appeal for example will be considered by adding a colour scheme.

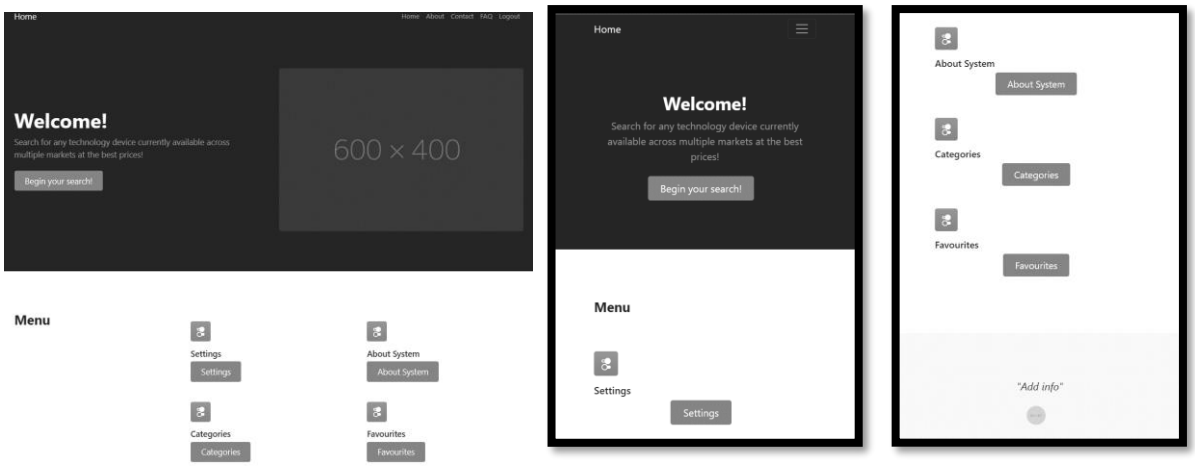


Figure 9: Initial webpage and mobile design

4.4. Database Design

4.4.1. NoSQL Vs SQL Databases

The two types of databases are NoSQL and SQL databases. NoSQL databases are known for their "simpler execution process as it avoids the usual complex SQL optimisation techniques" (Ali et al., 2019: Section 4). They offer a schema-less database and solve issues with data accessibility as they enable fields to be added to records without the structural barriers that come with SQL databases. Because of NoSQL's versatility, developers have access to a wider range of databases that go beyond conventional models.

On the other hand, when working with SQL databases, data is confined to a table structures. In comparison to NoSQL databases, SQL databases have stricter schema restrictions, which restrict their capacity to be flexible.

4.4.2. Chosen Database Type

This price comparison system will be using SQL. This is because NoSQL databases are not suitable as they are more suited for dynamic scaling – which entails improved efficiency when dealing with big data analytics. However, a SQL database is better suited for the price comparison and recommendation website as it will require a data structure which is more organised for "easier data querying" (Ali et al., 2019: Section 5, p.7). Data retrieval will be simpler because SQL databases use a schema for organising information which will be necessary for the products on the website. This allows for, strong querying capabilities that can be helpful for filtering and categorising product data, making the website more user-friendly.

It will also be relevant for user login and registration data. Subsequently, the integrity and consistency of the data is guaranteed by using SQL databases, which are better suited to handing the structured needs that comes with the aforementioned categories of data.

PHPMyAdmin is the chosen database platform as it has all the desired attributes previously mentioned.

4.5. Programming Languages

ID	Programming Language	Advantages	Disadvantages
1.1	JavaScript	Allows for dynamic and interactive webpages. It can be used for front end and back-end development.	The scripts are executed on the client side making it susceptible to manipulation. When scripts become too complex, it can lengthen load times of a webpage.
1.2	PHP	The scripts are handled on the server-side making it good for dynamic content generation and database querying. PHP has a lot of resources such as documentation online, making it easier to work with when errors are encountered.	In larger projects, PHP can be difficult to debug as it's not very well structured for readability. The language does not come with inbuild security so if security measures are neglected, it can put a website at risk.
1.3	Python	Python is regarded to be a simple language as commands can be written in a lot shorter amount of line than other languages such as Java. Python has a large number of libraries and web frameworks such as Flask which is standardised for building strong web architectures.	Due to the large amount of libraries and frameworks, python poses a steeper learning curve than alternatives which makes maintenance difficult. In systems that need low level optimisation such as a website with high traffic, python is not well optimised to run as well as alternatives.
1.4	Java	Java has a lot of libraries and web frameworks for web development which can help develop complex websites faster. Java is also known of its scalability which is great for a web application that handles high amounts of data.	Java is a complex language that requires depth of knowledge to be used efficiently to its full capabilities which can lead to slower development times. Java may often take longer to compile due to its complex nature. This will in turn slow down the user experience of a web application.

Table 8: Programming Languages

HTML and CSS are markup languages rather than programming languages. For the purpose of organising and presenting information on a website, HTML is essential to the structure and content on a web page. Although while HTML may have significant design restrictions, it is nevertheless a widely accepted standard that is supported by all current web browsers. Thus, HTML is a need for the web application.

In addition, CSS will be a great pair to HTML as it provides more control over the website's visual appearance, including fonts, colours, and layout. This makes CSS an excellent complement to HTML.

CSS also allow for responsive design proving flexibility and control over the components of the design of the webpage.

While Python, and Java each have their own merits, they may not be as suitable for this specific project. Java and Pythons potential for lengthening load times when scripts become complex, make it a less desirable option. Python's steep learning curve and suboptimal performance in high-traffic websites may pose challenges for a price comparison site. Lastly, Java's complexity and potential to slow down the user experience due to longer compilation times limit its suitability for this project also.

4.5.1. Chosen Languages

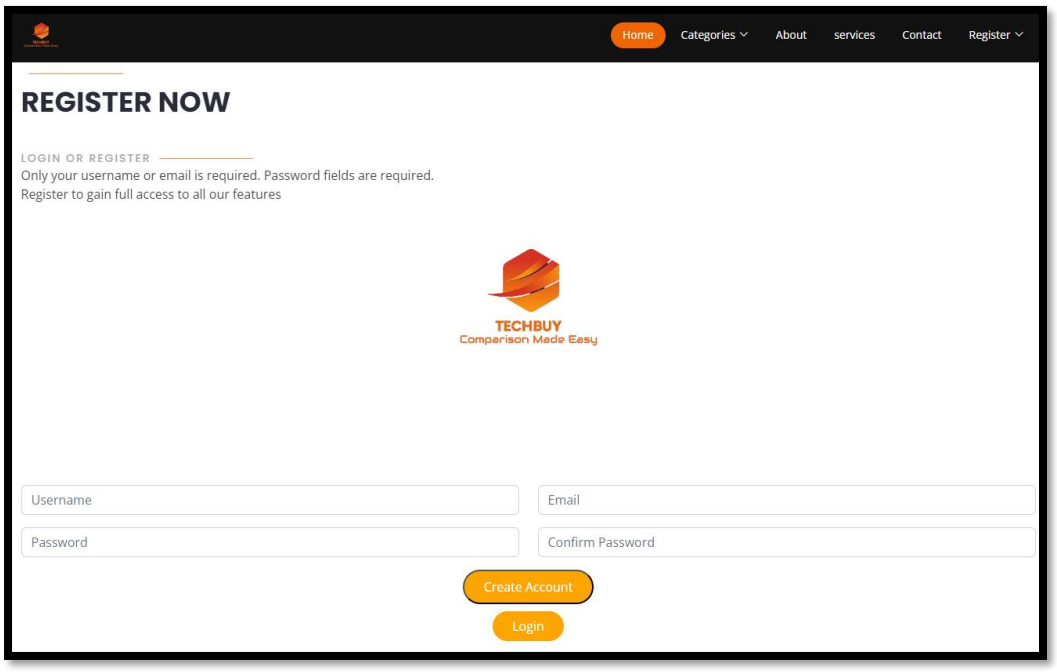
In summary, the combination of PHP, JavaScript, HTML, and CSS is the most appropriate choice for the price comparison site, given their strengths in server-side handling, content structuring, querying and visual design control.

4.6. Technical Implementation

To begin, choosing a suitable name is important for a brand that wishes to be successful. Therefore, the name chosen for this comparison website was 'TechBuy.' The entire code for the project is available in Appendix C.

4.6.1. User Interface

Making the user interface for the website was the first step in the implementation process. One of the most important things that was considered with the UI was to make the website responsive so it can be used on mobile devices or screens with different aspect ratios. Naturally, the home page, login and register page will be first pages the user will see. There a bright colour scheme with plenty of what space was chosen to appease the users interest. The home page, and registration pages are shown below in figure 10 in desktop and mobile aspect ratios.



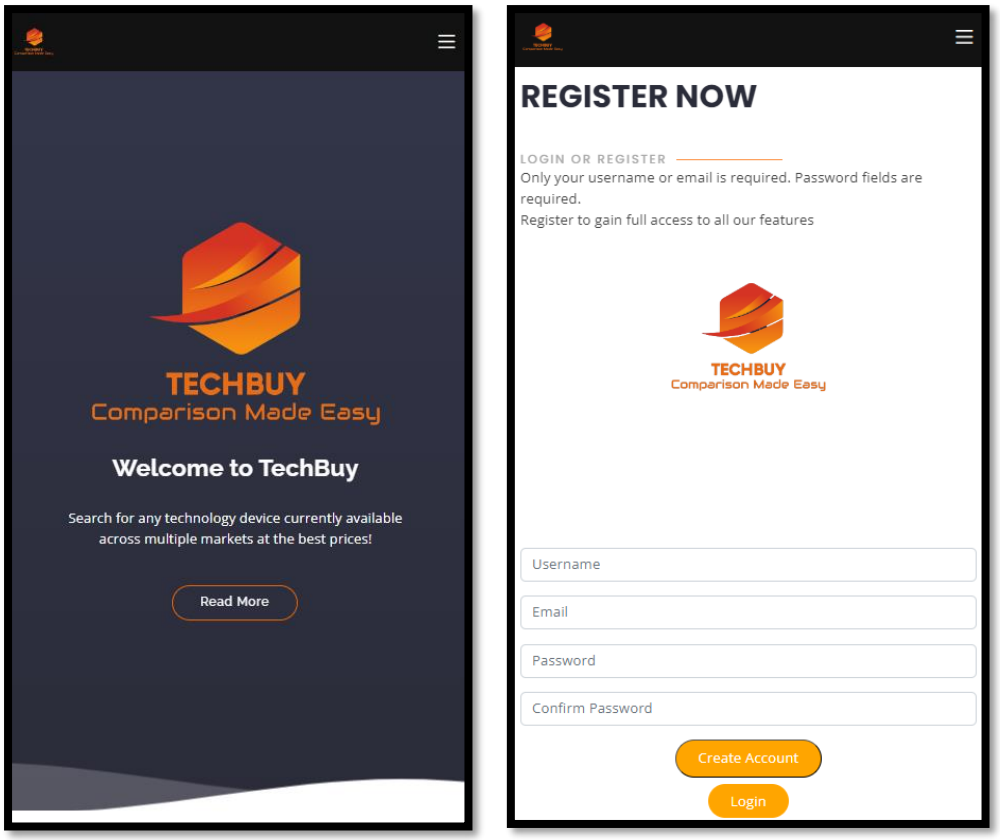


Figure 10: Home & Register pages

In order to make the design responsive, the chosen web framework used was Bootstrap. This is achieved by using a fluid grid system that adjusts the layout of the containers on the webpage dependent on the aspect ratio its bebing viewed in including zoom levels.

As discussed in Section 2.6.2 UX functionality criteria, the use of a consistent colour scheme is implimented and follows that of shades of oranges, pruples and whites with standardised black text on white spaces. This bold appraoch will keep the user engaged while using the system.

4.6.2. Login and Sessions

Using figure 7's use case diagram for reference, a key feature of the website is to allow users who are registered and log in full access to all features while unregistered users are limited. So, to make the login system, PHP and MySQL were required to enable to process of creating a login session for registered users. This was done by building a login form consisting of a username, email and password as discussed in Section 2.1: Introduction in HTML and CSS and then storing the inputted information in a database table on 'PHPMyAdmin' using PHP scripts once the 'submit' button is clicked on the form.

Next, the user is redirected to the login page using the PHP 'header()' function. In order for the user to then login, the user must enter either that username/email and password into the login. The user's email/username is then checked to see the ID of the entry on the database and check is the username/email they entered matches the password linked to that ID. If the information is incorrect, an error message will display letting the user know either that email/username or password was wrong or else the login check will be accepted, and session will be created for the user using the

inbuilt PHP Super-Global '$_SESSION['logged_in_user']' as shown in figure 11.

```php
session_start();

function getLoggedInUserFromSession($loggedInUser)
{
    if (isset($_SESSION['logged_in_user'])) {
        $loggedInUser = $_SESSION['logged_in_user'];
    }
    return $loggedInUser;
}
```

Figure 11: Session code

4.6.2.1 Login Security

To ensure the security of the login process, when the password was initially sent to the database, it was hashed using the inbuilt PHP function 'password_hash' (which is a bcrypt technique) to encrypt the password safely while it is stored in the database (shown in figure 12). This is a case of risk reduction as discussed in Section 3.4.

```php
$password = password_hash($password, algo: PASSWORD_DEFAULT);

$sql = "INSERT INTO login (username, email, password) VALUES ('$username', '$email', '$password')";
```

Figure 12: Security Code

When the user is logging in, the hashed password is then queried form the database and stored in a variable so it can be passed through the inbuilt PHP function 'password_verify()' (shown in figure 13) that checks if the password entered in the login form matches the one in the database and if it does a session begins. This makes it harder for attackers to access passwords even if the database is compromised.

```php
if (password_verify($password, $row['password'])) {
    // Password is correct, set session variable and redirect
    $_SESSION['user_id'] = $row['id'];
    $_SESSION['logged_in_user'] = $row['username'];
    header( header: "Location: landing_page.php");
    exit;
```

Figure 13: Password Verification Code

A bonus to using the Super-Global variable '$SESSION' was that the session saves the user's information – meaning the user can access the website without having to enter login details again unless the session expires. Furthermore, prepared statements such as the 'mysqli_real_escape_string' function which escapes special characters in the username and password inputs are used to defend the login form against SQL injections. This is a case of risk avoidance as discussed in Section 3.4.

4.6.3. Comparison Function

The compare feature is the most important feature that Techbuy has to offer and in this section, the implementation processes will be detailed. To begin, the comparison system begins on the product catalogue page where the products are displayed for the user to see.

4.6.3.1. Product catalogue page

On the product catalogue pages, the products saved on the database are queried and displayed in containers as shown in figure 14.

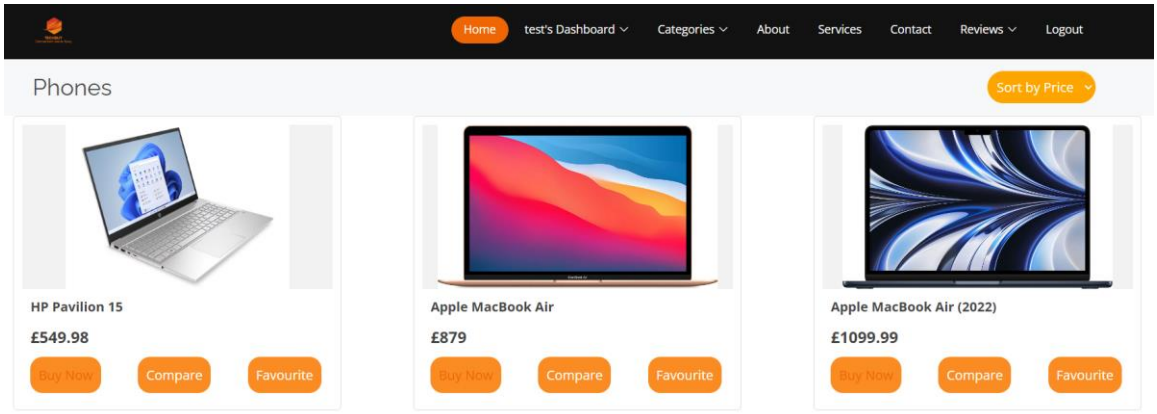


Figure 14: Product Catalogue Page

The method used to display each phone in separate containers is done by firstly querying the database to get all necessary data for every product that falls under a specified category. In figure 15 below, it is for the 'phone' category.

```
// Query the database for phone information
$sql = "SELECT id, phone_model, price, link, image, details FROM phones WHERE category = 'phone'";
```

Figure 15: Database Query Code

Then the script uses an if statement to check if there are any rows stored in the '$results' variable which is where all the results of the queries that were found in the database is stored. If there are more than 0 rows, then the loop begins displaying each row in the '$results' variable in individual containers which are triggered for each new row. The image URL is fetched from the database using $row["image"] and is formatted using CSS to makes sure it fits in the image container. Likewise, the price and the product model are fetched from the database using a similar method ($row["phone_model"] and $row["price") and displayed in the container.

As for the buttons, the 'Buy-now' button is linked to the first 'link' in the databases URL which takes the user to the third-party page to purchase their chosen product.

However, the compare and favourites buttons serve more functions. Firstly, both the buttons redirect to the register page is the user is not logged in using a combination of PHP and JavaScript to check for a session variable. If a session variable is not found the redirect function is called sending the user to the register page. Below in figure 16 and 17 is the code for the compare button.

```
<?php
//Compare button only works if user is logged in
if (isset($_SESSION['user_id'])) {?>
    <button class='buy-now' style='margin-left:40px;' onclick='comparePhone(<?php echo $row["id"]; ?>)'>Compare</button>
    <?php } else {?>
    <button class='buy-now' style='margin-left:40px;' onclick='redirectToRegister()'>Compare</button>
    <?php }
```

Figure 16: Favourite Button Code

```
// Java script to link compare button to compare page and pass id to the URL
function comparePhone(phoneId) {
    window.location.href = "compare.php?id=" + phoneId;
}
function redirectToRegister() {
    window.location.href = 'register.php';
}
```

Figure 17: JavaScript for redirect and comparePhone() functions.

Next, when the compare button is clicked, because it has a unique ID based on the product's ID from the database, a logged in user will be redirected to the compare page with the unique ID saved in the ‘phoneId’ variable being passed to the URL for reference on the compare page.

4.6.3.2. Compare Page

In order to display the product, the user is interested in, the script first checks for the ‘phoneId’ passed into the URL using ‘isset($_GET['id'])’. If it is found, the script assigns the value of the ‘phoneId’ to the ‘id’ parameter and then the following SQL script retrieves the requested row of that product from the table and stores it in the ‘$result’ variable. The variable is then checked and if there is more than 0 rows in it, the information is displayed in the same way it was displayed on the product catalogue page with an extracted function but with more information about the individual products (taken from the ‘details’ column in the table).

The code in figure 18 shows this process with the addition the SQL query involving the reviews which will be covered in the ‘reviews implementation’ section.

```php
<?php
// Get the id of the phone to compare from the URL
if (isset($_GET['id'])) {
    $id = $_GET['id'];

    // Query the database for phone information with the given id, and its reviews
    $sql = "SELECT phones.id, phones.phone_model, phones.price, phones.link, phones.link2, phones.link3, phones.image,
    phones.details, AVG(reviews.rating) AS avg_rating, COUNT(reviews.id) AS num_reviews FROM phones LEFT JOIN reviews
    ON phones.id = reviews.product_id WHERE phones.id='$id' GROUP BY phones.id";
    $result = $conn->query($sql);

    // Display the phone information
    if ($result->num_rows > 0) {
        while ($row = $result->fetch_assoc()) {
            extracted($row);
        }
```

Figure 18: Product to Compare Code

At the top of the compare page, the user is prompted to select a product to compare. The HTML <select> element is used to create a dropdown form that will allow the user to select a product to compare with the product already displayed on the screen. PHP code is then used to SELECT all the rows of products WHERE category = for example ‘phone’ and only the column ‘phone_model’ will be selected from those rows. All the phone models will then be displayed as the drop-down options for the user to compare the product with. This is shown below in figure 19.

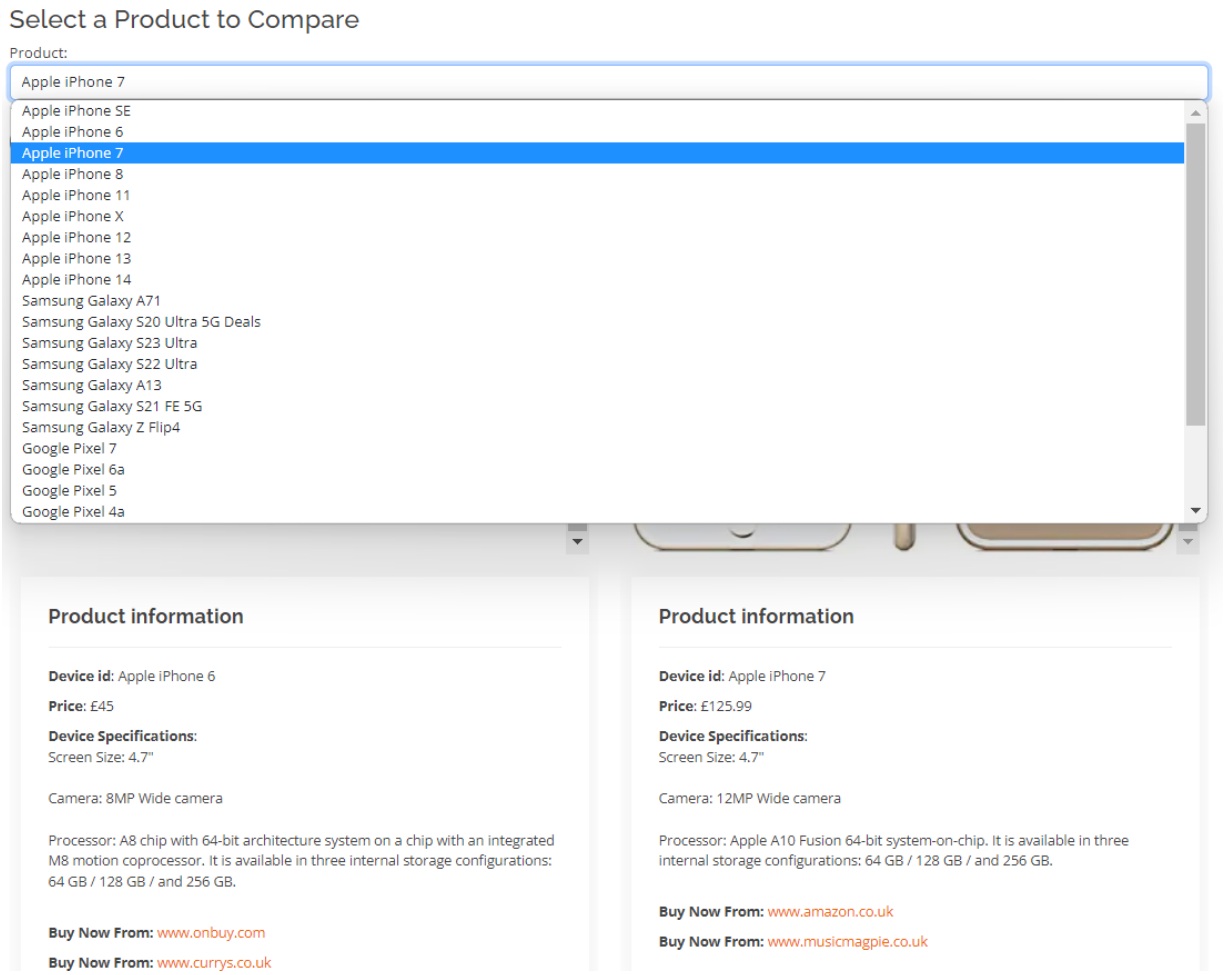


Figure 19: Compare Page

Above, shows two different products being compared. They have multiple links offering the user multiple retailers to purchase the item from. It also consists of the phone name, the price, and the product specifications. From the drop-down tab, all the different products in the same category can be selected to be compared.

4.6.4. Favourites Function

The favourites' function allows the user to save a product to their favourites page while shopping, so they do not forget an item they liked. The favourite button works in a similar way to how to comparison button does. If the user is not logged in, the button redirects to the register page and if there is a session active, the item in that container they clicked on is given an ID which is passed into the URL and is moved to the Favourites page.

4.6.4.1. Favourites Database

The favourites table consist of the following colums: 'id', 'user_id', 'phone_Id', 'phone_model', 'phone_price' and 'phone_image'. The primary key of the table is the 'id' which auto increments every time a new item is added to the favourites table. The 'user_id' an 'phone_Id' contain foreign keys link to the ID of the login table and the ID of the phones table so each users' favourites can be stored with a unique ID for each product ID.

```
function addToFavourites(phoneId) {
    // Retrieve the phone details from the phone-card
    let phoneCard = document.getElementById("phone-card-" + phoneId);
    let phoneModel = phoneCard.querySelector(".phone-model").innerText;
    let phonePrice = phoneCard.querySelector(".phone-price").innerText;
    let phoneImage = phoneCard.querySelector(".phone-image").style.backgroundImage;

    // Store the phone details in the database
    let xhr = new XMLHttpRequest();
    xhr.open("POST", "add_to_favourites.php");
    xhr.setRequestHeader("Content-Type", "application/x-www-form-urlencoded");
    xhr.onreadystatechange = function () {
        if (this.readyState === 4 && this.status === 200) {
            // Show an alert that the item has been added to favourites
            alert("Added");
        }
    };
    let params = "phoneId=" + phoneId + "&phoneModel=" + phoneModel + "&phonePrice=" + phonePrice + "&phoneImage=" + phoneImage;
    xhr.send(params);
}
```

Figure 20: Favourites' Function

4.6.4.2. Favourite Button

Using JavaScript, the addToFavourites() function is called when the favourites button is clicked. The 'phoneId' variable is passed into the function which is a unique identification method of which product was clicked on and the phones model, price and image are subsequently passed as well from the container using DOM manipulation. DOM manipulation provides the 'getElementByID' and 'querySelector' functions which are used to manipulate the data int Strings so they can be sent as variable parameters in the XMLHttpRequest.

The XMLHttpRequest makes a POST request to 'add_to_favourites.php' which is a server-side script that manages the how the details extracted from the phone container in which the favourite button was clicked will be added to the 'favourites' table in the database. A default encoding type for form submissions is then set using the RequestHeader. Listener is then used to monitor the state of the request and once the favourites button is clicked, the status will change from 4 which is the ready state to 200 which means a successful response has been received. The user is then subsequently sent an alert letting them know that their item has been added to the favourites. The parameters (phone details) are then concatenated to a String which is sent using the send() function to the favourites page. This code is referenced in figure 20.

4.6.4.3. Favourite Page

The scripts on the favourites page handle the display of a favourited product, the deletion of a favourited item and the redirection of the page to the relevant compare page based on what item was favourited. The display of the product and the button leading to the compare page are the same as discussed in the 'Compare Function' section.

As for the deletion of a favourited item, the process in the inverse of adding to the favourites page. A phoneId is passed into the deletion function, and the XMLHttpRequest makes POST request to 'remove_favourites' script which contains PHP and SQL scripts to delete an item based on the 'phoneId' passed to it from the 'favourites' table.

4.6.5. Reviews Function

Another important feature that Techbuy houses is the review section for its products. The review section can be found at the bottom of the compare products page allowing users to leave comments on a product they have viewed and also view existing ones. The implementation of this feature is as followed.

4.6.5.1. Review Database

Firstly, a 'reviews' table is used to store data retrieved from the form on the webpage and store it in the database. The table has contained the following columns: 'id', 'product_id', 'rating' and

'comment'. The 'id' columns is set as the primary key allowing each review to be linked to a different product in the database. The 'product_id' contains a foreign key linking to the 'category' of the product the review was left for so that those reviews can only be accessed when that category is being viewed on the website.

4.6.5.2. Displaying Reviews

The script that fetches the data from the database is based on a given ID and its reviews from the database. This is done using the 'JOIN' function in MySQL as the 'phones' table is joined to the 'reviews' table using 'LEFT JOIN' statement. The results are also grouped by ID so that a products reviews are all saved under the same ID - shown in figure 18. To display the reviews, the databased is queried and saved into a variable '$result' which is then looped through using 'fetch_assoc()' function and displayed in the HTML code. Figure 21 below shows the review section one the webpage.

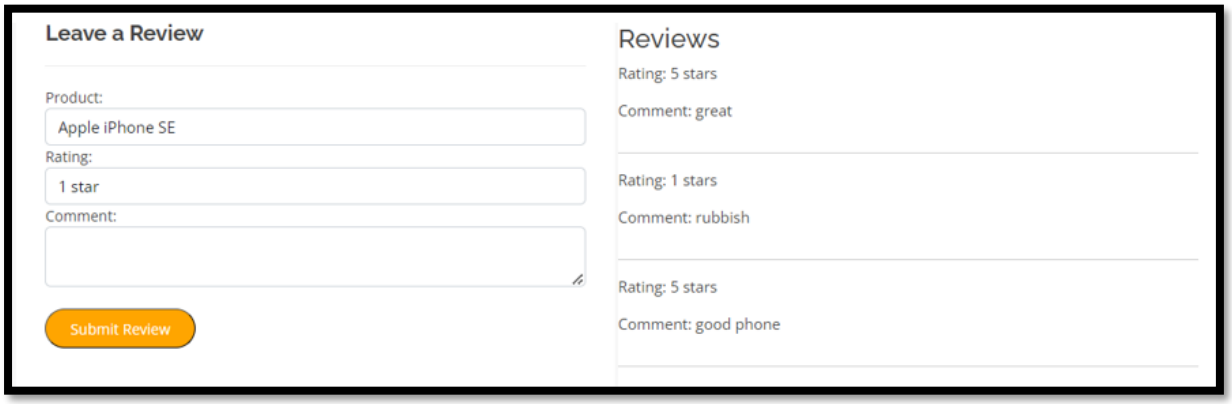


Figure 21: Review Section

4.6.6. Recommendation Function

The primary goal of the recommendation system is to recommend similar products to that of which the user is viewing as the devices may be compatible with each other or the user is likely into that specific brand of product. This section will describe how the system was implemented to fulfil this purpose.

Firstly, as the compare page carries the ID of the device being viewed in its URL, the product ID is retrieved through this using the '$_GET['id']' variable. Next a list of Strings containing keywords relating to the brand of every product stored in the database is added to a list (e.g. 'Apple', 'Sony' and etc). In order to get the products that have the keywords in them, a function called 'findKeyword()' searches through the current products IDs row in the database in the column called 'phone_model' and the first keyword found in that column that matches any of those in the list is saved to '$current_product_keyword' variable. The entire database is then queried in the 'phone_model' column - using SQL to get all the products with that same String that matches the current keyword variable. All the products that are found to match that keyword that is not the current product is then added to an array called '$product_ids' and finally, a function randomly selects an ID from that array to pick a product that will be displayed. The necessary details are taken from that IDs row and displayed on the webpage using HTML and CSS of that shown in figure 22.

Figure 23 shows what the system looks like displayed on the webpage.

```
echo "<div class='portfolio-details-slider'>";
echo "<div class='align-items-center'>";
echo "<div class='product-img'>";
echo "<div class='portfolio-details-slider swiper'>";
echo "<div class='phone-image'><a href='" . $row["image"] . "' data-gallery='portfolioGallery'
        class='portfolio-lightbox preview-link' title='" . $row["phone_model"] . "'><img src='" .
    $row["image"] . "' alt='" . $row["phone_model"] . "'></a></div>";
echo "</div>";
echo "</div>";
echo "</div>";
echo "</div>";
```

Figure 22: Display Reccomendations Code

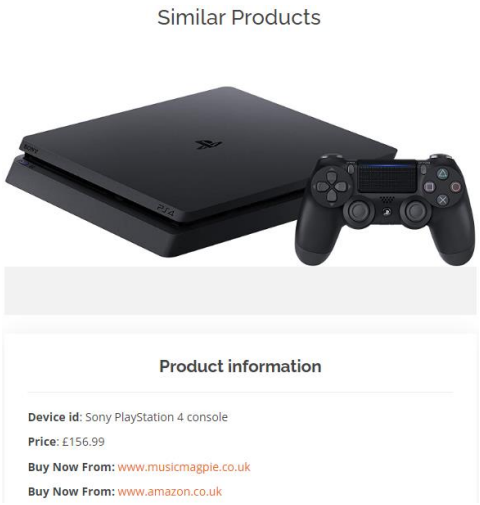


Figure 23: Recommendation System

4.6.7. Edit Account Details

As discussed in Section 2.6, one of the essential functional requirements is given the ability to the user to delete their account. To implement this feature, the 'if (isset($_POST['delete_account']))' is used to check if the delete button is clicked. If the button is clicked, it runs an SQL query first deletes all the users favourited items if there is any from the 'favourites' table. After this or if the user had no favourited items, another SQL query to delete the users account where the 'id' of the user in the table matches the session ID of the logged in user.

Additionally, to expand on this feature, the user is also allowed to update their account details. This does by using SQL queries to check if the fields such as email or username is empty. Those which are not empty are updated using the new account details the user enters into the HTML forms. The 'if (isset($_POST['save_changes']))' function checks if the save changes button has been clicked. If it has, the script using the POST super global to get the new details the user entered and updates the database.

Security is upheld while executing this process by using the 'htmlspecialchars()' function in the form used to allow users to update their account details. This function prevents injections of malicious code which may be passed into the webpage. Figure 24 shows the user settings page. Also the confirm() function linked to the delete button helps to prevent an accidental deletion as it requires confirmation before the action is executed.

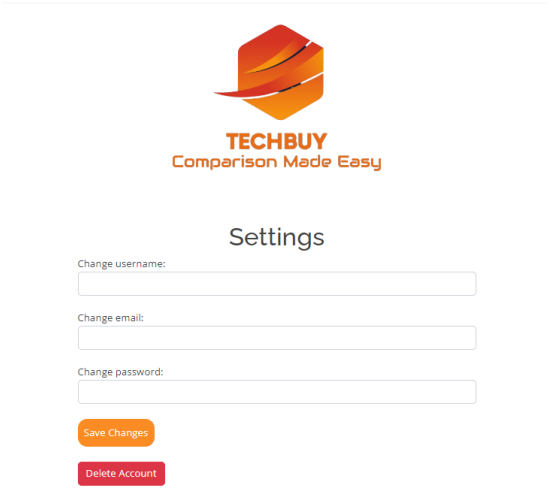


Figure 24: Settings Page

4.6.8. Third-Party Buy Links

The most essential part of the website is the links to the third-party sites that the user will purchase the item they wish to buy from. It was intended that an unregistered user will only be able to access one link which is not guaranteed to be the cheapest link. This buy now link can be accessed from the product catalogue page shown in Figure 14. The other place the user can access the buy links is through the comparison pages. On this page the user is given access to all the available links where they can compare to see which retailer has the cheapest prices. This can be seen in figure 19.

To implement the third part links, a HTML button element is created and mapped to an anchor tag which when clicked, runs an SQL script to retrieve the data in the 'link' column from currently selected product based on its ID. It is stored in the '$row' variable and linked to the button referencing the third-party webpage using the 'href' attribute.

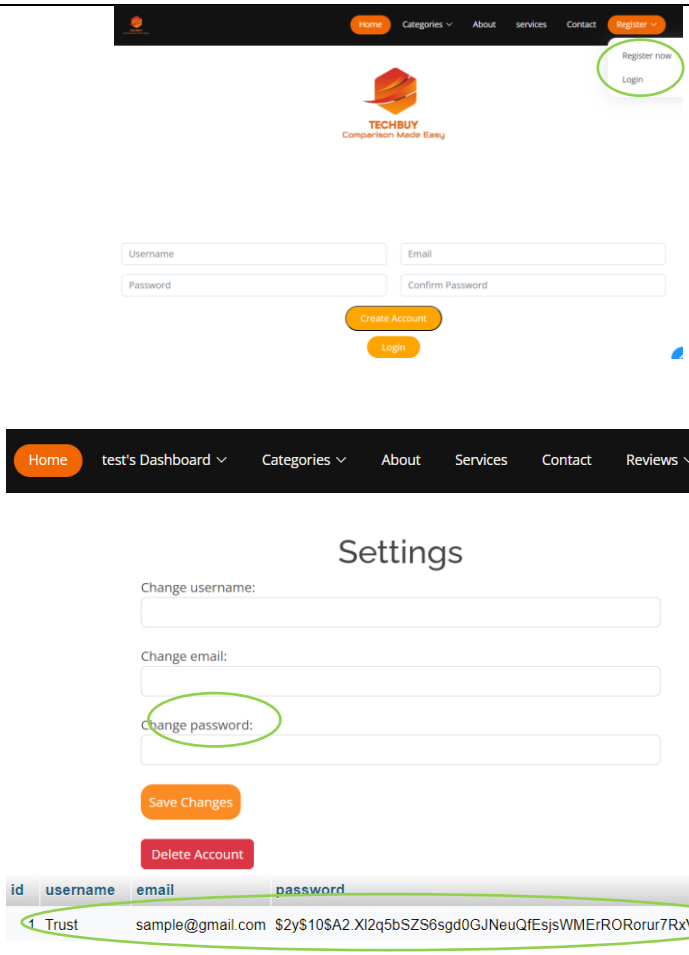
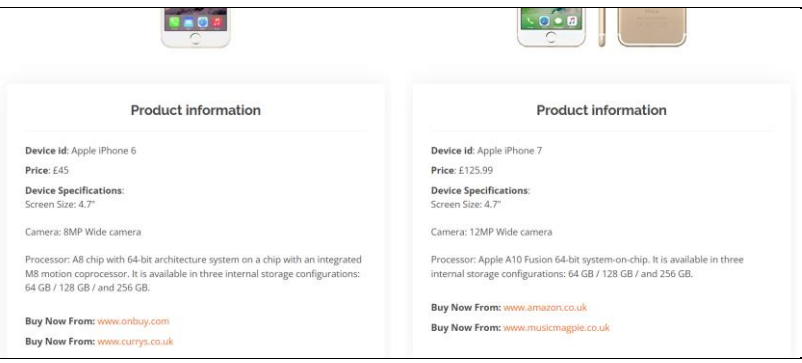
Section 5: Evaluation

5.1. System Testing

This section will cover the functional and non-function requirements set for the system and if they were achieved or not. Furthermore, tests such as, cross platform, security, and user acceptance testing will be carried out to determine how well the system is designed and if it fulfilled its criteria for success.

5.1.1. Requirements Testing

Functional Requirements Testing

ID	Actual Outcome	Success Criteria	Success
1.1		The website must give the users an option to register to the system. Users must be able to log out. Users must be able to delete their account. Users' login details must be added to the database once registered.	✓ ✓ ✓ ✓
1.2		The website must allow users to compare two products side.	✓

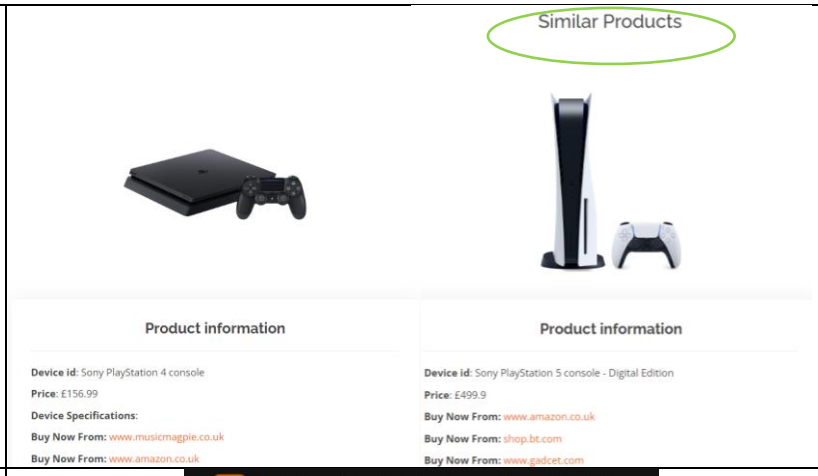
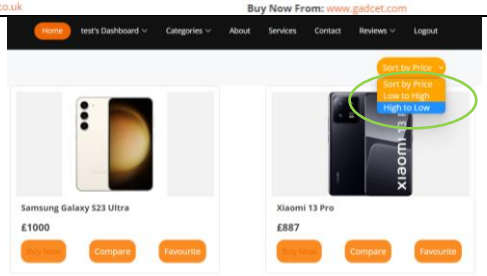
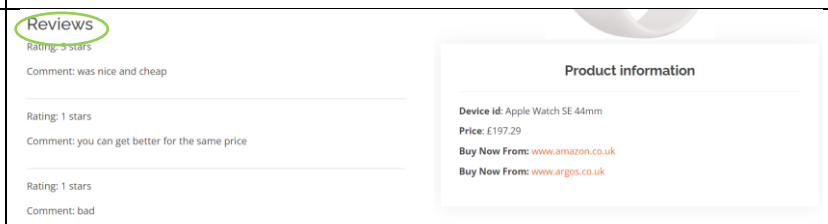
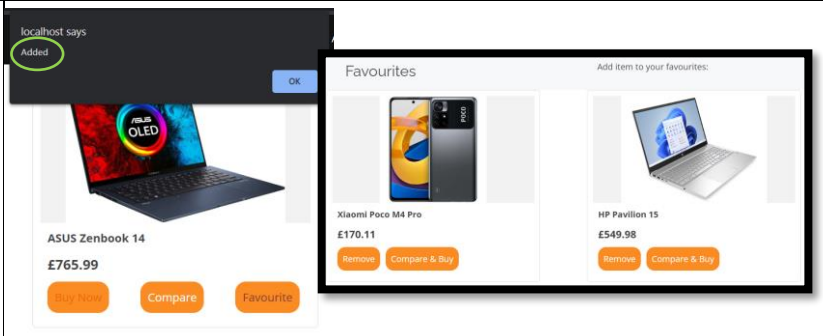
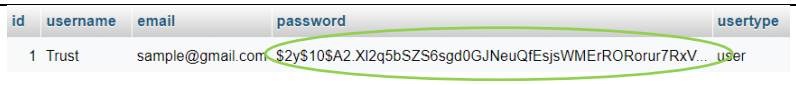
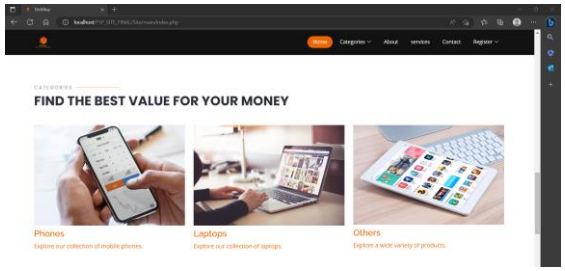
1.3		The website should have a recommendation system to suggests products to users based on the product they are viewing.	✓
1.4		The website must allow users to filter and sort search results based on different attributes, such as price, ratings and reviews.	✓
1.5		The majority of products with available reviews and ratings should be visible to users.	✓
1.6		The website must allow users to add products to their favourites for later reference.	✓
1.7	Due to time constraints, this was pushed down the priority list. It is also worth noting that various accessibility options are already inbuilt into systems and web browsers that the website will be used on. This includes zoom features, colour themes and other text to speech systems that are built into phones and browsers.	The website should have accessibility features to support disabled users	✗

Table 9: Functional Requirements Testing

Non-Functional Requirements Testing

ID	Actual Outcome	Success Criteria	Success
2.1	OOP principles such as inheritance and encapsulation were used to reduce the amount of repeated code and protect variables from illegal access. The best data structures for each datatype were also used, images were compressed to reduce load times and the number of SQL queries were kept to a minimum.	The website must have fast response times and retrieve data efficiently.	✓
2.2	This has been achieved through using a scalable database like PHPMyAdmin as it is capable of handling large amounts of data.	The website must be able to accommodate increasing numbers of users and products added to the database.	✓
2.3		The websites database must hash the user's login information for safe encryption.	✓
2.4	The website it able to run on all web browsers and different devices. Evidence: website running on Microsoft Edge and Safari on an iPhone.  	The website should work well with different browsers and devices including mobile.	✓
2.5	Evidence can be seen in ID 2.4 of table 10 and in figure 10.	The website should adjust to resizing or different screen sizes.	✓
2.6	The website makes use of CSS to create an aesthetically pleasing look that ticks the boxes of what makes a good UI/UX design as pointed out in section 2.6.3. Simple navigation Responsiveness Accessibility Personalisation User feedback Security and trust Consistency Error prevention and recovery Making effective use of white space	The website should be appealing and follow the latest design conventions.	✓

	Cross-browser compatibility		

Table 10: Non-Functional Requirements Testing

5.2. Security Testing

As discussed in section 3.4: Risk Assessment, it is important to plan for potential risk and possible ways to manage and avoid them and their consequences. This section will show how well each of the mentioned risks and their possible solutions where implemented.

ID	Risk Description	Actual Prevention	Success

1.1	SQL injection through login/registration form to access database.	Password Hashing:
		`$password = password_hash($password, algo: PASSWORD_DEFAULT);`
		Sanitisation of user input to stop SQL injections:
		`if ($_SERVER["REQUEST_METHOD"] == "POST") {`
		`$username = mysqli_real_escape_string($conn, $_POST['username']);`
		`$email = mysqli_real_escape_string($conn, $_POST['email']);`
		`$password = mysqli_real_escape_string($conn, $_POST['password']);`
		`$confirm_password = mysqli_real_escape_string($conn, $_POST['confirm_passwor`
		Closing database connections to stop illegal access:
		`mysqli_close($conn);`
		Session management to ensure only authorised access is given:
		`function getLoggedInUserFromSession($loggedInUser)`
		`{`
		`if (isset($_SESSION['logged_in_user'])) {`
		`$loggedInUser = $_SESSION['logged_in_user'];`
		`}`
		`return $loggedInUser;`
		`}`
			✓

1.2	Potential of phishing link scams replacing product links.	Protection against cross-site scripting (XSS) attacks by escaping output on the 'Buy Now' links:
		`<button class='buy-now'>`
		`<a href='<?php echo htmlspecialchars($row["link"], flags: ENT_QUOTES); ?>'>Buy Now</a></bu`
			✓

1.3	Malware attacks such as trojan horse virus.	Due to time constraints, it was determined that the likelihood of a malware attack happening was not high enough as other various protection measures created a soft barrier of protection.	✗
1.4	Thind party attacks: potential of a third-party site being hacked and indirectly misleading users.	Research was done into which retailers had the best security for their website. A vast majority of the retailers have strong protections for their site which inadvertently makes the user safer as well as their services are being provided through this website. This includes frameworks such as (AWS) Amazon Web Service which is very widely used across e-commerce sites.	✓
1.5	Data corruption: software errors leading to inaccurate data being displayed.	The database tables followed standard practices like using the correct datatypes for data, assigning primary and foreign key constraints to uphold data integrity. Also, Normalisation techniques were used such as the First normal form (1NF) to give each table a primary key to uniquely identify each record. The second form (2NF) is also followed as each non-key column depends wholly on the primary key. This can be seen in the 'phones' and 'favourites' tables. Finally, the third Normal Form (3NF) was maintained as each non-key column depend only on the primary key column and not on any other non-key column. In the 'phones' table, each column depends only on the 'id' column. In the 'reviews' table, each column depends	✓

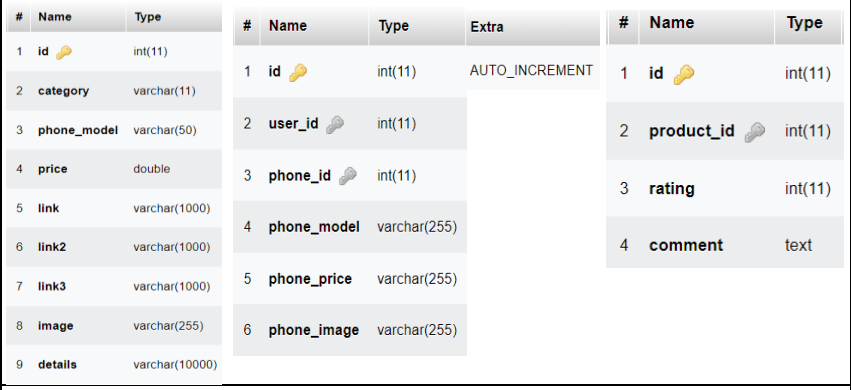
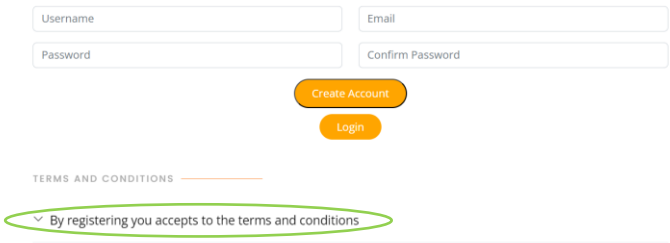
		only on the 'review_id' column. In the 'favourites' table, the 'favourite_date' column depends only on the 'user_id' and 'phone_id' columns. Evidence: Phones table favourites table reviews table  	
1.6	Legal and regulatory issues: Failure to follow data protection laws lead to potential fines and reputation damage.	By providing the user with terms and conditions before registering, it explains legal procedures and risks that are associated with using the site to avoid any legal action.  	✓
1.7	Technical issues: potential for a host server downtime leading to a crash	000Webost has been chosen to host the website on. This hosting platform comes equipped with customer support so that if in the case of any problems, they can help with trouble shooting.	✓

Table 11: Security Testing

5.3. User Acceptance Testing and Findings

The following section is based on a user acceptance test survey conducted to find out how the system held up when it was used. The survey covered the following areas: Ease of Use, product information quality, the technical performance, user satisfaction, data protection and any potential improvements (The entire survey can be found in Appendix B).

5.3.1. Ease of Use

From the survey, the consensus was that the website was straightforward to use which was one of the main goals for the non-functional requirements as it creates a smooth experience. This result suggests that the choice of placement of things such as the buttons on the navbar, and a clear guide

on how to use the website which included images were effective in enabling a seamless experience.

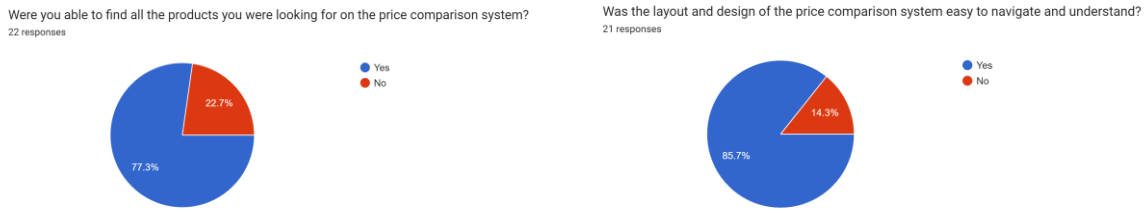


Figure 25: UAT Ease of Use graph

5.3.2. Product Information and Availability

The majority of the people tested leaned towards indicating that the product information provided was clear and enough. This is likely due to the inclusion of each device's specifications, image, and price comparisons. Also having multiple retailers linked to a single product likely provided the user with more freedom of choice which prompted this outcome. This suggests the system was successful in its presentation of extra information to help users make a more informed decision when paying was necessary. However, some users expressed a wish for a wider selection of goods and categories.

Figure 26: UAT Product Information Clarity graph

5.3.3. Technical Performance

The majority of users did not encounter any significant technical difficulties during the testing which demonstrates that the system was generally reliable. However, contrary to some of the steps taken to prioritise scalability to increase the responsiveness of the website, a few users reported occasional slow loading times. This may will be a future area of development to optimise the system's performance and ensure a responsive website to improve the user's experience.

Figure 27: UAT Technical Performance graph

5.3.4. User Satisfaction

Most users were willing to recommend the price comparison system to others, and overall satisfaction levels were high. This positive feedback indicates that the system effectively addresses users' needs and offers a valuable tool for finding the best deals on products. Continued monitoring of user satisfaction and implementing improvements based on feedback will be essential for

maintaining high levels of user satisfaction – as was discussed in Section 2.5's literature reviewing covering similar systems like Google shopping.

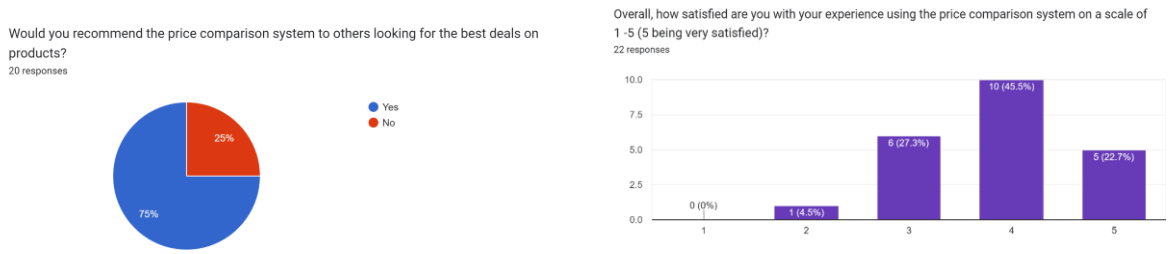


Figure 28: UAT User Satisfaction graph

5.3.5. Privacy and Data Protection

This question area showed that the users were generally comfortable with the personal information that was requested at the registration process as it was not too personal due to the choice, they could either leave a proxy username or just an email address along with a password. Some expressed interest in learning more about how their data would be protected. This highlights the importance of providing clear and accessible information about data storage, protection, and privacy policies to build trust and confidence in users as was discussed in section 2.5.

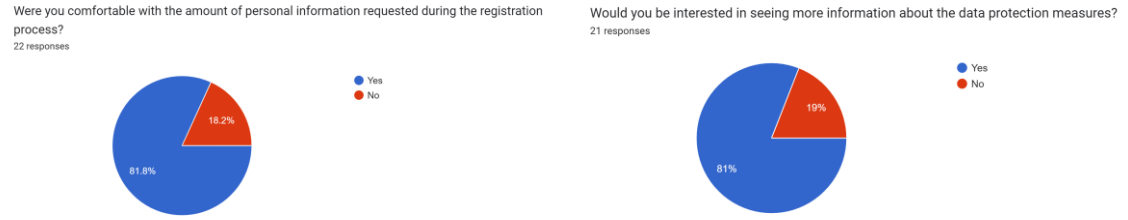


Figure 29: UAT Data Privacy Graph

5.3.6. Potential Improvements

The UAT's findings identified several potential areas for improvement that users would like to see implemented which could further improve the website. These include integrating alerts for price drops and developing a mobile app for increased accessibility rather than just relying on the website. Addressing these suggestions will further increase the system's accessibility to users and promote long-term user engagement.

In conclusion, the user acceptance testing for the price comparison system (TechBuy), revealed that the system effectively meets user expectations and provides a valuable tool for finding the best deals on technology products on the market. By addressing the identified areas for improvement and considering user feedback for additional features, the system can continue to evolve and offer an increasingly powerful and user-friendly platform for comparing product prices.

5.4. Project Aims Evaluation

These are the initial aims and objectives set at the beginning of the project and this section will cover if they were fulfilled or not.

5.4.1. Project Aims Checklist

Aims and Objectives	Success
Research into the most common practices for web development, security measures, and user experience design.	✓
The website should be capable of displaying the product details, customer reviews, prices, and the cheapest place to buy a product clearly.	✓
The customers confidential details such as emails and passwords will be encapsulated by effective security controls such as encryption to protect user data from potential security threats.	✓ Partially. Only the password was encrypted from the login details
Functionality of the website will be tested so that user feedback for further improvements can be obtained.	✓
Analyse user feedback and make necessary changes to the website to improve the user experience and security measures.	✗ Although user feedback was obtained, due to time constraints the feedback can only be used for future improvements.
The website must be fully functioning, ready to provide product details, customer reviews, and the best price for a product.	✓
To guarantee that user data is protected from potential security threats, security controls must be applied successfully.	✓
The website must be simple to use and offer customers a satisfying browsing experience.	✓

Table 12: Aims and Objectives Checklist

5.4.2. Evaluation

There are several aspects that ensured that the aims and objectives where met. In this section, the successes will be evaluated as well as the reasons why certain objectives where not achieved.

The website was successful in creating an intuitive user interface which enabled easy navigation, price comparison and use of other features like favouring items. This is because everything was labelled well and clear to read which is linked to the successful secondary research done on UI/UX in section 2.6 shown in tables 2 and 3. Also, research that was done into Google shopping and PriceRunner in section 2.5's Literature review was integral to how information was organised on the webpage as it followed other successful models.

Furthermore, implementing features such as the price sorting filter and categories was important to achieve the goal of letting the user focus their search to a specific price range or certain type of product. It was also important to ensure the favourites feature worked which is why it was high priority. These features allowed the users to have a personalised experience which was one of the main goals.

On the other hand, the website did not have live updates because there was lack of research done into real-time data updates such as web scraping. This limited the website to being manually updated and populated with data which is time consuming and tedious.

Finally, another aspect that was not achieved was building trust with the consumers by being transparent in data collection and storage policies. The website could have provided more information on how their data would be stored and for what reason the data was being collected to improve the users trust in the system.

5.5. Further Development

Upon conducting a thorough examination of the user acceptance testing results, the project aims checklist, and the analysis of the TechBuy price comparison system, it has become evident that certain aspects warrant further development. These improvements will work to enhance the system's functionality, user experience, and overall performance. The subsequent sections portray these key areas, proposing potential improvements which could be incorporated in future iterations of the project.

5.5.1. Expand Product Selection

A major aim of this project was to provide a system to online shoppers that could compare prices across as many product ranges as possible. Although this was the case the product categories were fairly limited to household technology in three main categories. Subsequently, the website suffered from its limited scope in terms of product range. However, introducing a larger database of products outside technology and a more comprehensive database of information on the products can solve this issue. By integrating these additional product types and brands of technology products, such as tablets and larger home appliances, the system could develop into a more versatile tool for users, thereby attracting a higher amount of user engagement.

5.5.2. Implementing Web Scraping for Real-time Data Updates

The current system works of a preprepared database which is quite limiting as to update the product catalogue, it has to be done manually which takes time. However, research into alternative way to populate the database indicate that integrating web scraping techniques (Sirisuriya, 2015) would advance the system a lot. This is because web scraping allows for real-time update of data, prices and other information that would be pulled from the third-party retailers linked to the website. Web scraping could be accomplished using technologies such as Python, in conjunction with libraries like Beautiful Soup or Scrapy (L. Ruggeri, 2022), which are adept at extracting and processing data from multiple websites efficiently.

Furthermore, implementing web scraping techniques would also open the door to other features which can build on top of it. One of these features is to alert the user when prices drop or for promotions. This would be a vital addition which can set the system apart from others in the field as working in conjunction with web scraping, when the retailers' prices dropped it would instantly update and notify customers – leading to higher user engagement (J.M. Imlawi et al, 2022) with the platform, ensuring they receive timely information on the best deals available.

5.5.3. Performance and Optimisation

Another aim of the project was to ensure a fast and responsive website which was somewhat achieved. However, during testing and the UAT, it was found that the load times for some users were slow. This suggests the system needs further performance optimisation to bolster its responsiveness. Techniques such as lazy loading and caching (S.K. Shivakumar, 2020) could be employed to decrease load times and improve the overall user experience.

5.5.4. Social Media and Sharing Features

For a system that depends on customers and their referrals, it is important to try and increase the outreach of the website. Using social media integration and other sharing mechanics, this can increase user engagement and promote the platform. Implementing social media sharing of pages such as the favourites page, would help to promote the deals on the website - allowing users to distribute their favourited items to their followers. This could expand the platform's reach and contribute to its growth.

Section 6: Conclusion

In conclusion, the aim of the website was to create a user-friendly system that would help online shoppers make faster and better-informed purchasing decisions. This was outlined by the using the aims and objectives on performing extensive background research on similar systems, researching what makes a good user experience to attract and retain customers, and crafting robust system requirements through it. By using user feedback, possible further developments were also found as well as identifying any strong points to keep or add innovative ideas to support its function further.

The accomplishments of this project is reflected in the results of the user acceptance testing as it resembles a modern website in regards to its design, functionality and its usability. The Successful implementation of a recommendation system, a comparison feature and giving the users the ability to leave reviews on each product as well as view other reviews further improves the interactivity of the website – leading to higher engagement rates.

In reflection, many learning opportunities arose throughout this project such as the importance to understand user needs, choosing the right technology and programming methods to develop optimised software and the importance of effective project planning in regard to time, effort and managing risks. Furthermore, the importance of research was particularly highlighted as it prevents previously encountered problems and errors from being encountered again – making for a smoother development process.

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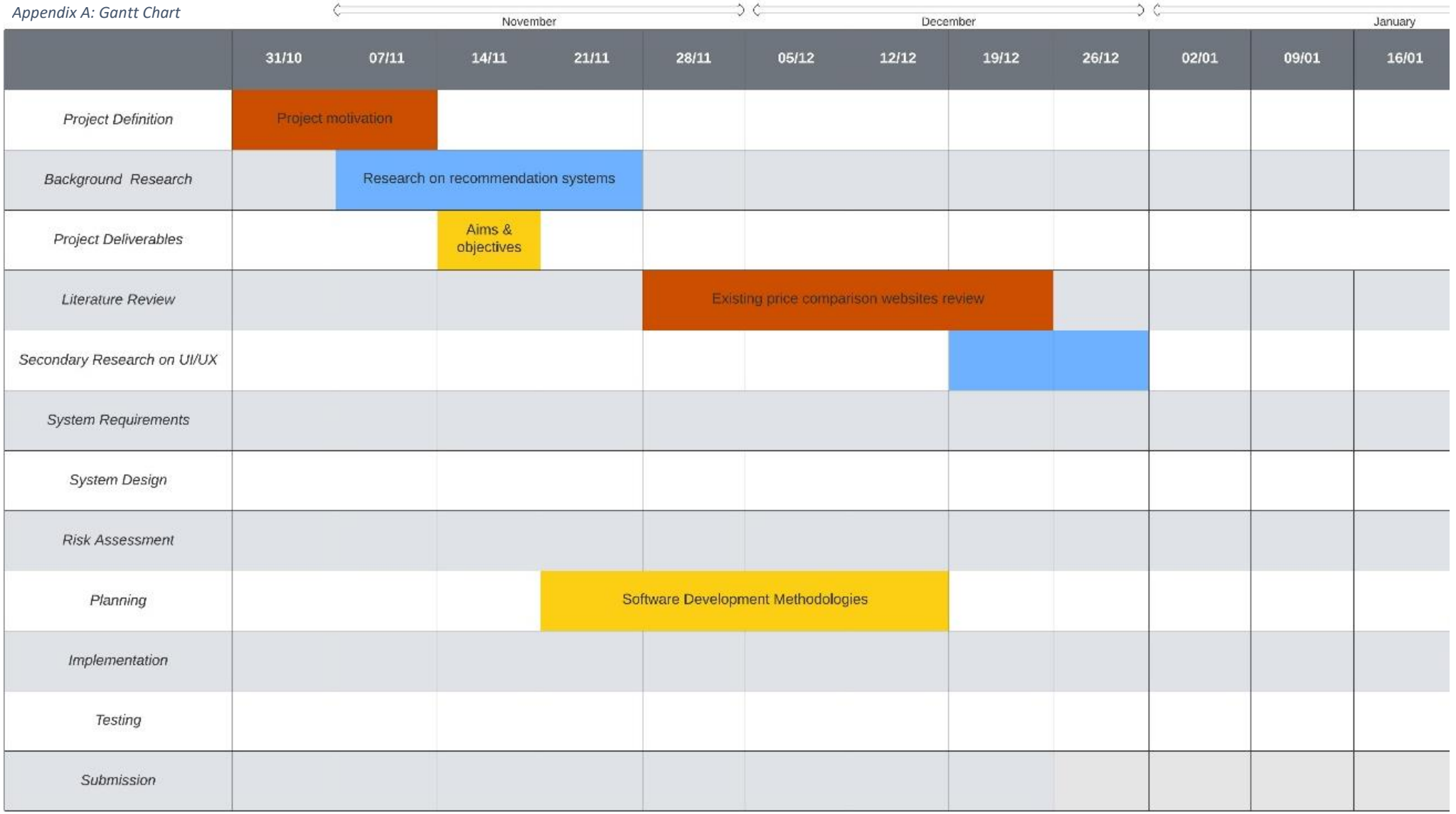
Appendix

Appendix A: Gantt Chart



	February						March				April			
	23/01	30/01	06/02	13/02	20/02	27/02	06/03	13/03	20/03	27/03	03/04	10/04	17/04	24/04
Project Definition														
Background Research														
Project Deliverables														
Literature Review														
Secondary Research on UI/UX														
System Requirements				Functional & non-functional										
System Design				Use case Diagrams	Activity Diagrams									
Risk Assessment							Risk identification and control							
Planning														
Implementation	Front-End Implementation				Back-End Implementation									
Testing					Continuous functional requirements testing							End-user testing		
Submission														

User Acceptance Test

Invitation

I would like to invite you to take part in a study forming part of my final year project.

Before you decide if you would like to participate, take time to read the following information carefully and, if you wish, discuss it with others such as your family, friends or colleagues.

Please ask me, my contact details can be found at the end of this information sheet, if there is anything that is not clear or if you would like more information before you make your decision.

What is the purpose of the study?

The aim of this project is to create a web product comparison system to help improve shopping experiences for users in terms of being able to see the best deals and recommendations available as well as adding new features such as leaving reviews and favouriting.

The aim of this specific study is to understand users' shopping experiences using the website but also to elicit information from end users to understand their priorities and what is relevant to them.

Why have I been chosen?

You are being invited to take part in this study because you have previously expressed your interest in shopping for the latest technological devices to me.

- You are 18+

- You have recently shopped online

What will happen to me if I take part?

If you decide to participate, you will be invited to take part in an online survey where you go through the website and then answer some questions from a questionnaire about your experience. The interview is designed to understand user shoppers' experiences using the website. The interview should take approximately 10 minutes of your time.

Do I have to take part?

No. It is up to you to decide whether or not you wish to take part. If you do decide to participate, you will be asked to read a series of consent statements regarding the use of the data you provide in response to the questionnaire. If you agree to the conditions,

please click the 'next' button to continue to the questionnaire questions, your completion and submission of which confirm consent. If you are unable to agree, please shut down your browser. You would still be free to withdraw from the study at any time up until you submit your responses without giving a reason; after submission, because your responses will be anonymous, it will not be possible to extract your data.

Will my taking part in this study be kept confidential?

Yes. The data collected will be anonymous.

If we need to collect personal data (such as a name and contact details) we will only use this for the purposes of contacting you to invite you to participate. The data we collect will be stored in a secure document store (paper records if applicable) or electronically on a secure encrypted mobile device,

password-protected computer server or secure cloud storage device. To ensure the quality of the research, Aston University may need to access your data to check that the data has been recorded accurately, e.g., for the purposes of audit. If this is required, your personal data will be treated as confidential by the individuals accessing your data.

What are the possible benefits of taking part?

While there are no direct benefits to you of taking part in this study, the data gained will give me an insight into users shopping experiences and help me understand their priorities and what they look for further improvements.

What are the possible risks and burdens of taking part?

Given the topic of the questionnaire combined with the fact that the data collected from you will be anonymous, we feel there is minimal risk to you in participating.

In terms of burden, participation will require approximately 10 minutes of your time.

What will happen to the results of the study?

The results of this study will be published in the final year project report of the student, wherein your identity will remain confidential.

The results of this study may be published in scientific journals and/or presented at conferences. If the results of the study are published, your identity will remain confidential.

Expenses and payments: There are no expenses or payments being provided for participation.

Who is organising this study and acting as data controller for the study?

Aston University is organising this study and acting as data controller for the study. Research data will be used only for the purposes of the study or related uses identified in this Information Sheet or Appendix A.

Who has reviewed the study?

This study was given a favorable ethical opinion by delegated authority of the Engineering & Physical Sciences Research Ethics Committee. What if I have a concern about my participation in the study? If you have any concerns about your participation in this study, please speak to the student and s(he) will do his/her best to answer your questions. Contact details can be found at the end of this information sheet. If the student is unable to address your concerns or you wish to make a complaint about how the study is being conducted you should contact the Aston University Research Integrity Office at research_governance@aston.ac.uk or telephone 0121 204 3000. Research Team Details Trust Aigobtsua, 200033246@aston.ac.uk, 07848972768

Megan Robertson, m.robertson8@aston.ac.uk

Thank you for taking time to read this information sheet. If you have any questions regarding the study please don't hesitate to ask one of the research team.

Instructions

Please go to the following link to test the website: https://techbuy2023.000webhostapp.com/Site/main/index.php

Tasks:
1. Login with the following details:
- Username: survey
- Password: SurveyPassword
2. Use the user guide on how to use the website
3. Navigate to categories
4. Compare any set of products
5. Favourite a product
6. Follow the links to purchase a product

1. How easy was it to use the price comparison system to find the best deals foryour desired products?

_____

2. Were you able to find all the products you were looking for on the price comparison system?

Mark only one oval.

- ◯ Yes
- ◯ No

3. Did you find the information provided on the product details page helpful in making your purchasing decision?

Mark only one oval.

- ◯ Yes
- ◯ No

4. Was the layout and design of the price comparison system easy to navigate and understand?

Mark only one oval.

- Yes
- No

5. Did you encounter any technical difficulties while using the price comparison system?

Mark only one oval.

- Yes
- No

6. Would you recommend the price comparison system to others looking for the bestdeals on products?

Mark only one oval.

- Yes
- No

7. Was the price comparison system able to save you time and money on your purchases?

Mark only one oval.

- Yes
- No

8. Were you comfortable with the amount of personal information requested duringthe registration process?

Mark only one oval.

- Yes
- No

9. Would you be interested in seeing more information about the data protection measures?

Mark only one oval.

- Yes
- No

10. What additional features would you like to see added to the price comparison system?

11. Overall, how satisfied are you with your experience using the price comparison system on a scale of 1 -5 (5 being very satisfied)?

Mark only one oval.

1 2 3 4 5

Appendix C: Website and Database code with Website Access

Website Code Available at:
https://github.com/Trustaig/Product_Comparison_System/tree/master
The database Schema is also included in the repository named: products.sql

Website Hosted at:
https://techbuy2023.000webhostapp.com/Site/main/index.php

Use the following details to Login to the website to explore all features:
Username: survey
Password: SurveyPassword

Appendix D: Project Diary

Project Diary

November 2022:

-Conduct initial research on popular e-commerce websites and their features.

December 2022:

-Create a detailed project plan, to show the main stages of the project and with deadlines for each stage.

From supervisor meeting:

- write about why I am using the languages I'm using (e.g. resources and compatibility (commonly used))
- talk about technology I wish not to use and why.
- unique idea: user reviews for products, second-hand marketplace.

January 2023:

- start work on the design of the website's user interface. Ask supervisor about different design choices and review my current design.
  From supervisor meeting:
  - logo for site
  - talk about site design (reason for design choice and ones I didn't choose)

February 2023:

- Start working on the back end of the website.
- Set up the database tables and write code to for welcome page and basic display of product information on the website.

March 2023:

Begin implementation of user registration and login functionality.

Use:

- PHP and SQL.

- work on my product comparison functionality.
- Implement a recommendation system.
- Implement favourite functionality.

April 2023:

Conduct final testing and debugging of the website.

- Supervisor meeting:
  - conduct ethics survey

- Conduct user acceptance testing with a small group to get feedback on the website's UI and functionality for evaluation.
- Submit final report and code and prepare presentation.