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Confidentiality Required?

NO

I give permission to make my project report, video and deliverable accessible to staff and students on the Project (Technical Computing) module at Sheffield Hallam University.

YES

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Abstract

Internet technology has advanced at such a high rate in the last decade it is far more beneficial for a business to provide an online service instead of having a physical presence. Most online services assume that the user is already technically competent and can use their website without any issues.

Unfortunately, a demographic of people still exist who lack fundamental digital skills. Consequently, they are unable to benefit from the convenience of online shopping, banking, and many other forms of online services.

This project aims to provide an interactive learning resource that teaches the user skills that are outlined in the UK Governments Essential Digital Skills' framework.

This project demonstrates the development process of the tool and the result of the target demographic using it. After testing and user feedback, the overall result was positive, and the final deliverable is a suitable resource for users who would like to improve their digital skills.

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1 Introduction

1.1 Project Background and Motivation

Lloyds Bank (2020) yearly consumer digital index proves that in the UK, over 11.3 million people lack full basic digital skills. To combat this, the government of the UK have launched an initiative called Essential Digital Skills (UK Government, 2019). The Essential Digital Skills is a framework that helps educating bodies identify computing skills that all adults should have.

As the Essential Digital Skills framework is extensive, producing a tool that covers every section cannot be achieved in the given timespan. Instead, the primary focus for this project is the transacting skillset. The UK government expect a user with transacting skills to be able to register and apply for services, buy, and sell goods and services, and administer and manage transactions online (UK Government, 2019).

Barnsley Adult Skills and Community Learning (ASCL) integrate the Essential Digital Skills framework within their learning. They are one of many institutions who have direct communication with the audience the project is attempting to help. They have emphasised that they are unable to find suitable tools where their learners can practice using online services such as banking and shopping.

Outside of learning institutions, over 80% of internet users claimed to be self-taught within 2020 (Lloyds Bank, 2020), meaning that people are willing to go out of their way to learn how to use online services.

This project will try to provide a resource for new users to come to grips with the internet on their own or with help from an educating body.

1.2 Project Aims

The main aim of this project is to create an online educational tool that covers certain criteria from one of the five modules within the Essential Digital Skills framework. To achieve this, the following objectives should be considered during the project:

1. Research a primary focus from the Essential Digital Skills framework.
2. Research relevant existing applications that provide a form of learning experience.
3. Identify a suitable development approach and research tools to assist the process.
4. Design an application architecture that uses frameworks and libraries that will help create a realistic and learner friendly experience.
5. Research application deployment and web application security.
6. Define a set of reasonable requirements and functionality for the application.
7. Develop and deploy a full stack application with use of a front-end, back-end and a database.
8. Test the application with cooperation from Barnsley Adult Skills and Community Learning.
9. Evaluate feedback and suggest areas of improvement for the application.
10. Conclude, when done correctly, if an online educational tool can be beneficial for users who lack online computing skills.

2 Research

2.1 Essential Digital skills

The Essential Digital Skills framework is sectioned into different online and offline computing skillsets. It covers a range of digital skills; from keyboard usage to solving problems with a spreadsheet.

The following is a list of transacting skills highlighted by the Essential Digital Skills framework that can be tackled with the use of simulating an environment (UK Government, 2019):

- Access and use public services online, including filling in forms.
- Upload documents and photographs this is required to complete an online transaction.
- Fill in online forms when required to complete an online transaction.
- Using appropriate websites or Apps, that enables the user to buy goods or services.

As 81% of users claim to use the internet for buying products and services (Lloyds Bank, 2020). The UK Government also highlight skills associated with this in the bullet points above, the project should consider teaching users how to use an online shop.

Transacting also includes the ability to complete forms and when considering the percentage of users using the internet for purchasing (Lloyds Bank, 2020), a payment form tutorial would also be relevant for the project.

Research from Lloyds Banks suggests that 9 million (16%) of users are unable to use the internet by themselves. This is further highlighted by some of the skill examples in the digital foundation section of the essential digital framework (UK Government). It suggests that users without foundation skills are unable to “locate the browser icon on a device and find a website”. Therefore, a virtual deliverable will result in a percentage of users that face accessibility issues, as a result, the project must consider and the best way for an inexperienced user to have access to the resource.

2.2 Existing Applications

Looking at existing applications that are in a similar category to this project will demonstrate how most sites handle interactions intended for educating the user.

2.2.1 Lloyds Online Bank

Lloyd's Bank provide an online academy of informational videos and are partnered with "Learn My Way". "Learn My Way" provide very basic, but interactive tutorials.

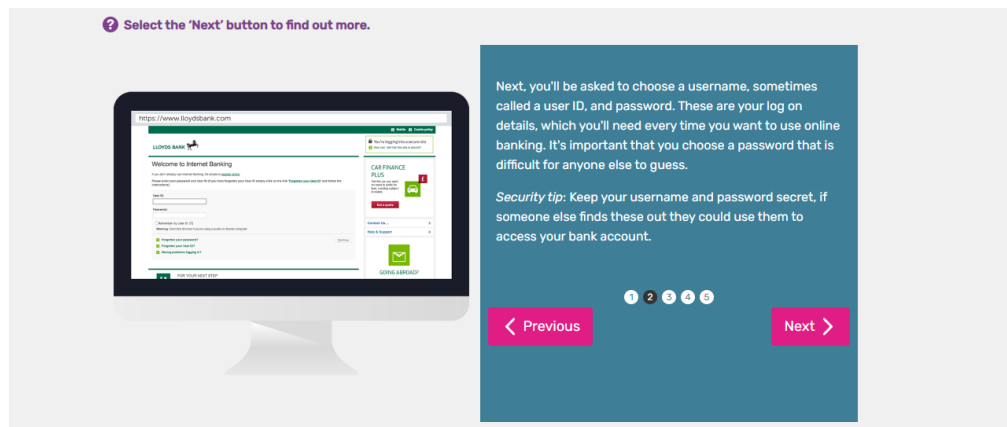


Figure 2.2.1: Lloyds Bank Learn My Way online banking information slides.

Figure 2.2.1 shows the style of tutorial provided by "Learn My Way". They provide slides of information along with screenshots. Whilst completing each task there is an abundance of information given to the user. This could be a lot to take in straight away, especially for users who are new. There are rare instances where the user can interact with the image on the screen shot, however, they are unable to directly interact with anything else. This provides a very static experience and does not allow for any form of interaction outside of the scope of the tutorial.

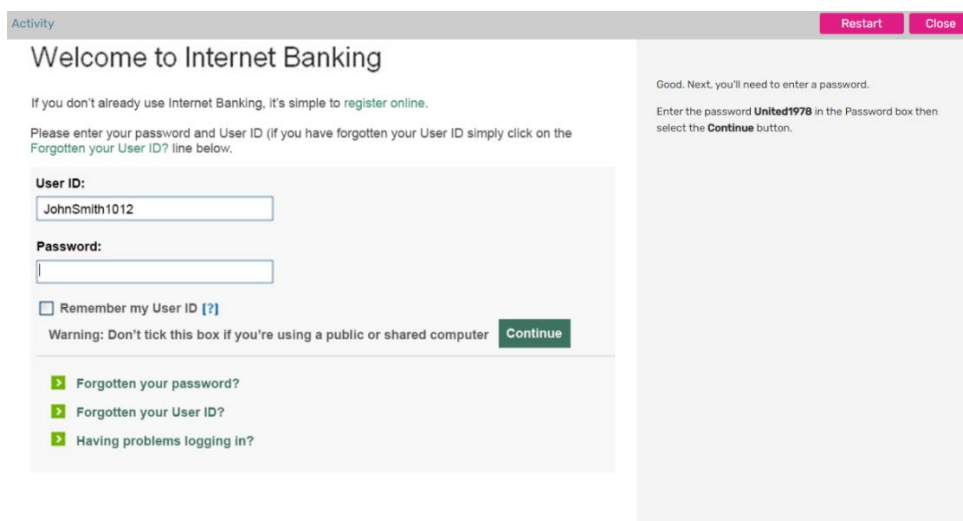


Figure 2.2.2: Lloyds Bank Learn My Way online interactive tutorial.

Figure 2.2.2 shows an example of a static interaction, where the user is instructed to login to the banking application. The tutorial provides a screenshot, which is then overlaid with a couple of interactive input fields.

2.2.2 NGPF Bank Simulator

Looking at an existing resource that simulates a real service should be taken into consideration. The NGPF Bank Simulator, is an American bank simulator, that requires a user account before accessing it.

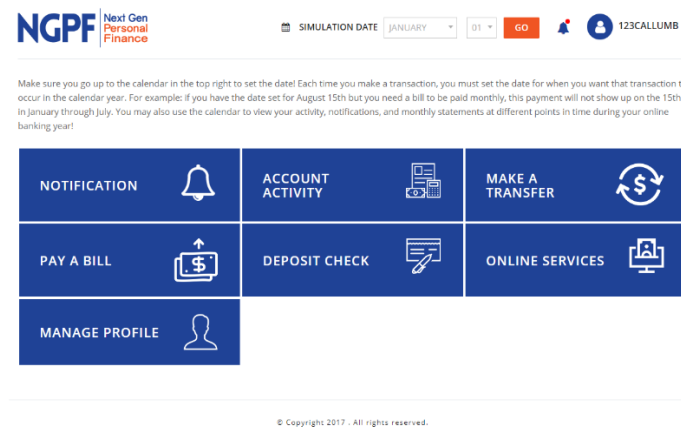


Figure 2.2.3: NGPF Bank simulation home.

Figure 2.2.3 shows that the simulation allows the user to experiment with features expected to be on an online banking service. The simulation is equipped with very realistic functionality, however, lacks the ability to teach the user. To use this as a learning resource would require assistance from an experienced user who would guide the learner through the simulation.

2.2.3 Kahoot

The project needs the ability to teach the user in an informative and interactive manner. Kahoot is an online game-based learning platform that has an effective way of keeping the user's attention using animation and a minimal amount of information on display at one time.

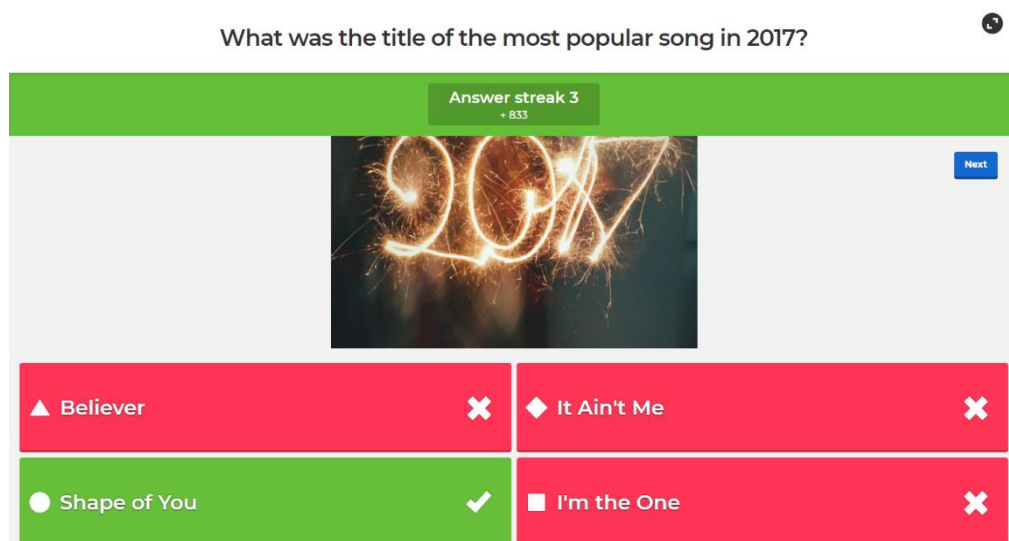


Figure 2.2.4: Kahoot from the perspective of the user answering a question.

Figure 2.2.4 demonstrates Kahoots approach for answering a multiple-choice question. The buttons are large and easy to click, the question is clear and given in a large font.



Figure 2.2.5: Kahoots access functionality with game pins.

Kahoot has a feature that allows users to join an active session without needing an account. As seen In **Figure 2.2.5**, Kahoot does this by generating a code that is used to access the game. This provides ease of accessibility and should be considered for the project as a method for users to login.

2.2.4 Existing Applications Conclusion

The existing applications exhibit features that can be implemented within the project to provide an ideal learning environment for the user.

Lloyds Bank has demonstrated the type of instructions the user should be given when learning about an online service. The learning style seems to contain a significant amount of information, which means note taking must be done by the learner. The project should incorporate this method of instructing the user, however, it should also ensure that the user is not suffocated with too much information at once.

NGPF's Bank Simulator shows that online services can be simulated. This is a tool that provides a safe environment for users to test their skills before using a real online bank. The project should integrate simulations as part of the learning experience as the user is more likely to become familiar with the types of interaction they are expected to perform.

Each existing application inhibits different learning styles. Lloyds Bank are aware they are targeting an audience that are unfamiliar with online services as they are very information driven. This is unlike the NGPFs bank simulator that assumes the user knows a little bit about online banking due to the fact there are no instructions given whilst using it. Kahoot is suitable for both an experienced and unexperienced audience as there is no direct need for the user to consume noteworthy information.

Kahoot demonstrates an effective approach for interacting with users and keeping their attention span on relevant information. The project should strive to always capture a

user's attention and make it obvious where and what users are supposed to be interacting with.

2.3 Software Development Tools

2.3.1 Development Methodology

Choosing the correct development methodology helps define how parts of the project, such as the requirements and the testing, will play a role in the final deliverable. The development must be organised, and the workflow should be approached in a step-by-step process. The first development methodology to consider is Waterfall.

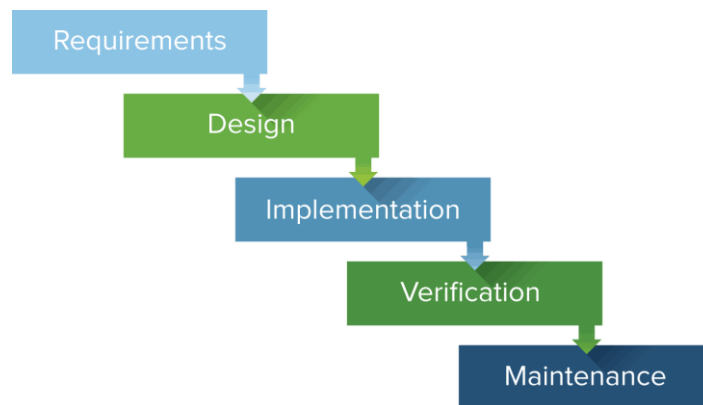


Figure 1.3.1: Waterfall development process.

Figure 2.3.1 shows the linear pattern Waterfall uses. The Waterfall methodology assumes that the specification for the project is well outlined within the requirements and design stage before the implementation begins. After the implementation stage, the product is seen as fully complete, and verification begins (usually with some form of user involvement). Further development is done as part of the maintenance stage.

As discussed by Measey (2015), a way to help define what methodology is the most suitable is by using the Cyfin framework. For example, the Cyfin framework identifies two domains where it is appropriate to use the waterfall methodology. It states that simple (obvious) domains where it is easy to define the exact product upfront, the waterfall methodology should be used. It is also possible to use the waterfall methodology in a complicated domain if the requirements are well defined, however, if this is not the case, the Agile methodology is more suited.

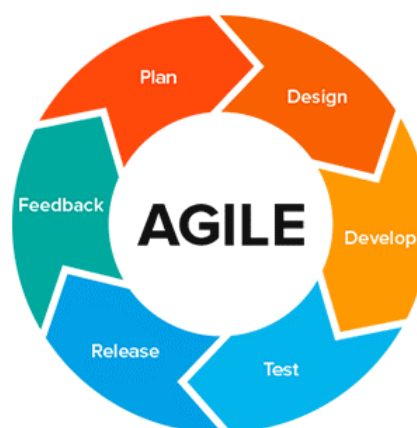


Figure 2.3.2: Agile development process.

As visible in **Figure 2.3.2**, the Agile development methodology is a process of constant feedback and development. Agile development consists of multiple sprints until the final product is ready. As highlighted by Measey (2015), the Cyfin framework states that Agile is recommended for a complex domain where the cause and effect today may not be the same tomorrow. Proving, the Agile model is very flexible to changes in requirements.

To conclude, the project should take an Agile development approach as waterfall methodologies incur too much cost, rework, and risk to be effective in the dynamic field of information management (McKnight, 2013). Constant feedback and integration with Barnsley ASCL will present an opportunity for constant improvement to the application. As this project is only being developed by one member, it is fair to assume the potential for incorrect decisions during the requirement and design stage. Agile has a very forgiving manner where issues can be highlighted and reattempted within the next sprint.

2.3.2 Development Software

Following the Agile methodology will require a set of tasks to be defined at each sprint. There are a multitude of software tools available that allows users to organise tasks.

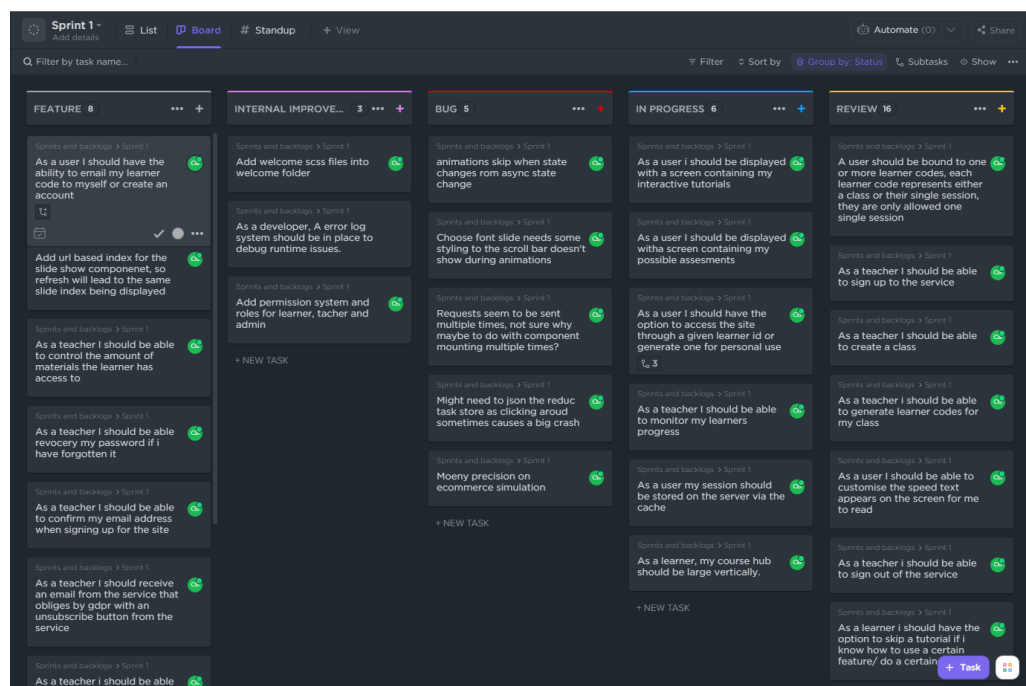


Figure 2.3.3: Click up sprint Kanban template.

Figure 2.3.3 shows a screenshot of the software “Click Up”. Click Up supports a range of task templates, one of which is a sprint board Kanban. This is perfect for task and bug tracking.



When starting a project, a back-up plan must be considered. Version control (VC) is a tool that helps store an archive of previous application versions that help avoid the

worry of an errant code change or a catastrophic disk crash (Loeliger & McCullough, 2012).

GitHub is a hosting provider where project code can be stored and supports version control functionality via Git (A command line VC tool). Alternatives exists, such as BitBucket and SourceForge, however, GitHub supports the widest range of integration across popular IDEs like Visual Studio and IntelliJ.

3 Design

When designing architecture of the application, the most appropriate programming languages and tools need to be chosen. The application will be split into three key areas, the front-end, the back end, and the database.

3.1 Front-end Architecture Design

3.1.1 JavaScript Bundling Eco-System

JavaScript is the most used front-end programming language, however, unlike a compiled language, lacks the ability to link two files and their functions together.

Bundling allows for JavaScript code to be merged into one file. This means that an additional layer of compilation is added. This additional layer provides a more maintainable approach to JavaScript development, as code can be modularised, split into multiple files, and syntactically checked before compilation.



There are multiple bundling libraries available that use the Node.js runtime environment. The most popular being Browserify, Webpack and Bower.

To improve maintainability further, instead of using vanilla JavaScript for the project, TypeScript will be used. TypeScript extends JavaScript by adding types. TypeScript saves time catching errors and providing fixes before the code is run. It will reduce the amount of runtime errors and results in a codebase that is easier to understand.

Making use of bundling will allow the use of SCSS, a scripting language that is compiled into CSS. SCSS reduces amount of styling code required by providing language features that CSS lacks, like variables and inheritance.

3.1.2 Single Page Application Frameworks

Using a single page applications approach means a webpage only changes content by redrawing what is already on the page instead of the user receiving a new page when they are redirected to a URL.

Advantages	Disadvantages
<ul style="list-style-type: none">• Enables a user experience much like a desktop application.• Site navigation is rapid as pages boiler plate content (header, footer etc) is already preloaded.• The app only requests information when it needs it instead of sending a full page with everything.• The JavaScript bundle is cached after the site has been visited once.	<ul style="list-style-type: none">• Increase loading time on initial page load due to JavaScript bundle size.• Switching front-end framework in the future is not a viable solution.• Difficult for search engines optimisations as site scanning for bots is harder to do due to the virtual dom.

Figure 3.1.1: Advantages and disadvantages of single page applications.

Figure 3.1.1 shows that using a SPA over a traditional website has considerable advantages. If the project is to use an SPA, then it must decide on a front-end framework like VueJS or ReactJS.

3.1.3 JavaScript Component Library

To save time during development pre-existing code in the form of node libraries will be used. An ideal library to use is a component library. Component libraries contain the most common components used in an application such as buttons, text fields and progress bars. They are already styled and built in an abstract way which allows for further modifications when integrating with applications.

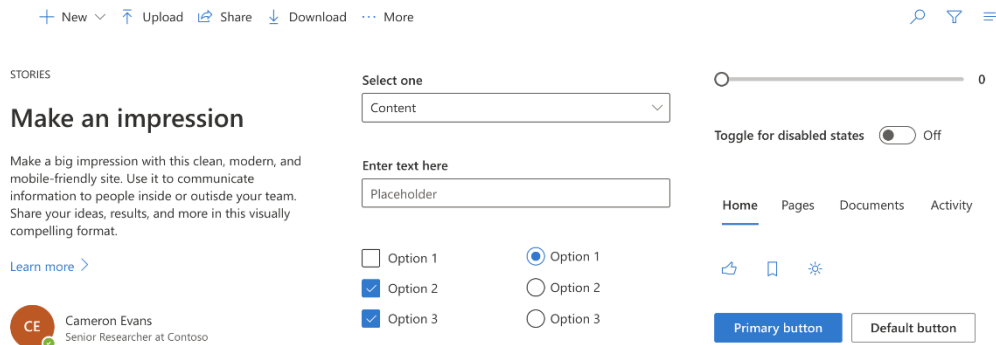


Figure 3.1.2: Fluent UI component examples.

Microsoft have developed Fluent UI (Previously Fabric UI), a component library containing common interface elements. (Examples on **Figure 3.1.2**). They are used within Microsoft's online version of Office 365. Fluent UI's documentation is directed at ReactJS. Choosing Fluent UI would heavily influence the project to use ReactJS as a front-end framework.

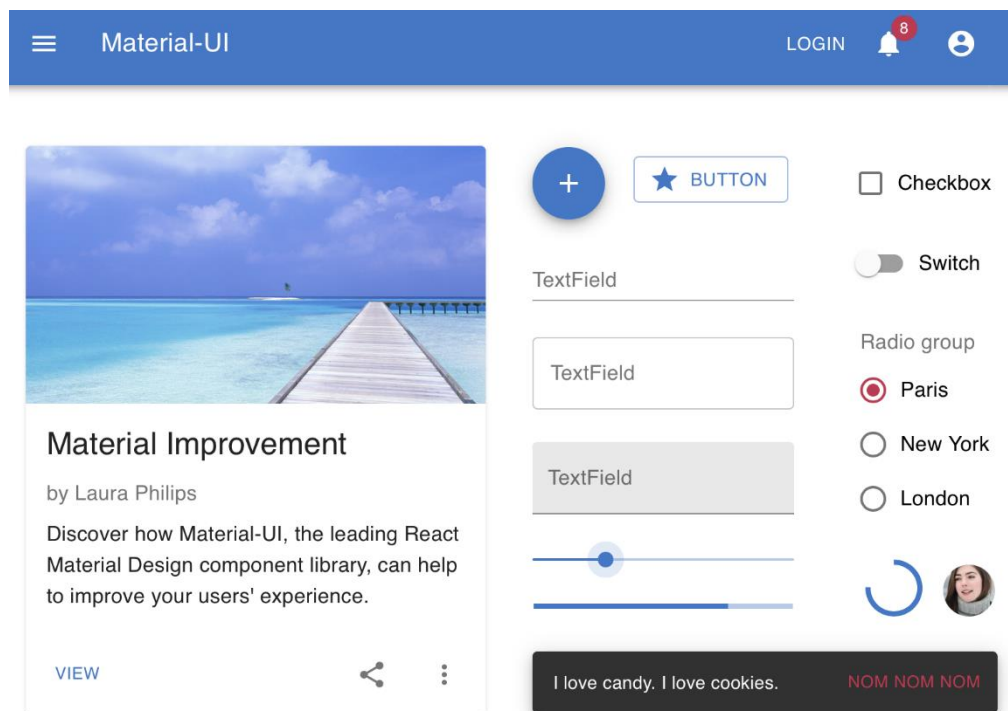


Figure 3.1.3: Material UI component examples.

Figure 3.1.3 shows Google's component library, Material UI. This is one of the most popular component libraries which has a wider range of elements than Fluent UI. It is built for both desktop websites and mobile applications.

Although Material UI will provide more elements to use, Fluent UI may be more beneficial, as users that have used programs like Microsoft Word will already be familiar with the application's interface.

3.2 Back-end Architecture Design

3.2.1 Cross Platform Back-end Frameworks



Cross platform frameworks can run on most operating systems. Choosing a cross platform framework will mean that when it comes to deployment, additional money does not have to be spent on a server. The two considerations for the back-end are to use Microsoft's .NET Core or ExpressJS (Using NodeJS runtime).

Node.JS ExpressJS	.NET Core
<ul style="list-style-type: none">• Cross platform• JavaScript - dynamically typed.• Great integration with NoSQL databases due to dynamic types• Suitable for JSON structured data• Large variety of community libraries.	<ul style="list-style-type: none">• Cross Platform• Relevant libraries made by Microsoft.• Libraries and Framework are very well documented.• C# - strongly typed.• Suitable for SQL database integration

Figure 3.2.1: ExpressJS vs .NET Core

Figure 3.2.1 shows what each back end has to offer. Using NodeJS with ExpressJS for a back end is more suitable when the application uses a NoSQL database. Whereas .NET Core has a specific set of libraries built by Microsoft for integration with a relational database such as SQL Server.

3.2.2 Database

There are multiple relational databases. The two to compare are Microsoft's SQL Server and MySQL.

SQL Server	MySQL
<ul style="list-style-type: none">• Suitable for large quantities of data• Can process large queries.• Microsoft's own documentation for .NET Core integration.• Has a cross-platform version called SQL Express.• Requires more processing power.• Requires a license to run in production on virtual machines.	<ul style="list-style-type: none">• Open Source• Cross platform• Lightweight• Easy to install and setup.

Figure 3.2.2: SQL Server vs MySQL

Figure 3.2.2 shows that SQL Server has a lot more features than MySQL, but this means it has more features than necessary for the project. MySQL may be a preferable approach due to it being lightweight and not as overkill as SQL Server.

A NoSQL database is also a valid option when considering a JavaScript back end, due to its inbuilt support for JSON data structures. Based on popularity and community support, the two NoSQL databases considered for the application are MongoDB and Redis.

Redis	MongoDB
<ul style="list-style-type: none">• Great performance due to caching features.• Easy to install and setup.• Can process up to 1GB at a time.• Requires more ram for caching features.• Takes more time to set up the application architecture/schema.	<ul style="list-style-type: none">• JSON based schema.• Easily scalable.• Large amount of community support and documentation• Application architecture/schema is easily setup.

Figure 3.2.3: Redis vs MongoDB

Figure 3.2.3 shows the features that should be considered when picking between MongoDB and Redis.

3.3 Architecture Conclusion

The most suitable back end for this project will be .NET Core. This is due to Microsoft's well documented libraries and integration with the Visual Studio IDE. Security and database interaction are crucial factors of a web server, and it may take a while to find the correct ones when using a NodeJS backend. As each NodeJS library is made by different developers, compatibility issues may also occur. It is best to avoid this entirely and go with libraries that are documented to be compatible. As for speed .NET Core will be sufficient, it is already far more lightweight than its predecessor (.NET Framework) and can handle more than 1.15 million requests per second with 12.6Gbps throughput (Ciliberti, 2017).

As influenced by Ciliberti (2017), using .NET Core on the back end also influences the decision to use React as the front-end framework as the project plans to build a highly sophisticated single-page application.

As the back end uses .NET Core, the ideal database would be to use SQL server due to Microsoft's database integration support. However, the application will not be storing a large amount of data and will not be processing many SQL scripts, therefore, a MySQL database will be the most suitable. This also avoids any issues with licensing that may have occurred from using the express version of SQL Server in production.

3.4 Prototype Deployment

3.4.1 Cloud Server Hosting

Fortunately, the current application design uses cross-platform architecture, this will help to reduce server cost hosting platforms, as a free licensed operating system such as Ubuntu can be used.

The two considerations for cloud hosting are Amazon Web Services (AWS) and Digital Ocean as they both allow the user to create virtual machines. Users will access the application by connecting via a web URL that points to a port that is open on the virtual machine.

Amazon Web Services	Digital Ocean
<ul style="list-style-type: none">• Huge collection of cloud services.• Scalable service• Verity of Virtual machines• Well suited for scalable and power heavy applications.• UK based servers	<ul style="list-style-type: none">• \$100 of free student credit• UK based servers• Wide range of tutorials associated with .NET Core and MySQL.• Variety of virtual machines

Figure 3.3.1: Amazon Web Services vs Digital Ocean

Figure 3.3.1 demonstrates the features of both providers. Digital Ocean seems the most suitable, due to their free credits for students. The application is not doing any form of heavy computing, so it is not likely to cost anywhere near the \$100.00 limit. Amazon web services provide such a vast collection of cloud services that navigating their control panel is often confusing and will require additional time to learn unlike Digital Oceans. Digital Ocean also provide useful tutorials for setting up a virtual machine that hosts a .NET Core project using a MySQL database which is relevant for the chosen architecture.

3.5 Requirement Specification

3.5.1 User Categories

The application is divided into two types of users: teachers and learners.

The importance of introducing teacher into the application is to organise and simplify the learner's experience. A teacher can create a classroom where they add their learners. This will generate a learner code that the learner can use to access the site. The teacher can track the progression of their learners and assist in their learning. This is a crucial part of the application as the learners are expected to lack fundamental digital skills so may require help accessing the application.

The application is heavily orientated to the learner's experience over the teachers as they are the target audience. The learner is to use the application as an interactive resource that will improve their digital skills. Learners are given courses which consists of multiple tasks. These tasks are to be completed within an online service simulation. There are two types of courses, an exam, and a tutorial. Tutorial courses will consist of tutorial slides which guide the user through the online service simulation. The exam course will test their ability to interact with the online service simulation without guidance.

3.5.2 Functional Specification

Here are the minimum functionalities a learner should have within the application:

- Login without the need to sign up for an account.
- Access a home page with a library of online tutorials and exams.
- Ability to interact with an ecommerce service simulation.
- Ability to interact with a payment form simulation.
- Follow an interactive tutorial, learning how to use the services.
- Ability to complete exams by accomplishing a set of tasks for the simulated service.

The prime goal of these requirements is for the learner to easily understand how to use an ecommerce service and fill in a payment form.

The minimum requirements for the teacher are as follows:

- Ability to sign up and login to the application with an email address and password.
- Ability to create a classroom in which learners can be added.
- Ability to create learners and generate learner codes for them to use to access the app.
- Keep track of learners by seeing how many exams and tutorials they have completed.

3.5.3 Non-Functional Specification

These specifications are quite important for the application. They indirectly affect the user's learning experience overall. If certain parts of text or interaction does not look or feel correct, the users will question if what they are doing is right or not. Failing to satisfy non-functional specifications will lead to a poor learning experience as the users already lack experience interacting with online applications.

The application should be fast to respond to all user interactions. An example of feedback would be a button highlighting or becoming animated to show that it is clickable when the user hovers over them.

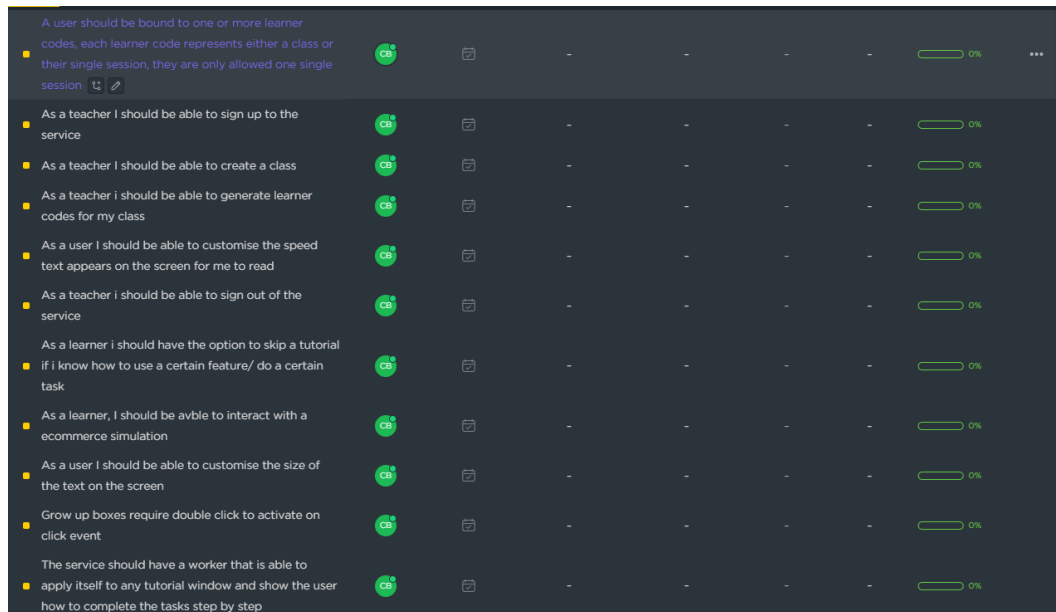
The application should not be buggy and have unexpected outcomes when interacting with certain functionality. This will confuse the user and degrade the experience.

This application should not break the laws of the European legal framework, the General Data Protection Regulation (GDPR). This means that users must be aware of all the information the system will be using that is associated with them.

The application should also abide by the General Data Protection Act (GDPA) which is the UK Governments implementation of GDPR. Adding high levels of security to the application should stop any of these laws getting broken. Teachers are required to enter a password and an email address. This data should be stored securely, and the application should have a layer of security that ensures that no user has direct access to data they do not have permission to view.

3.5.4 User Stories

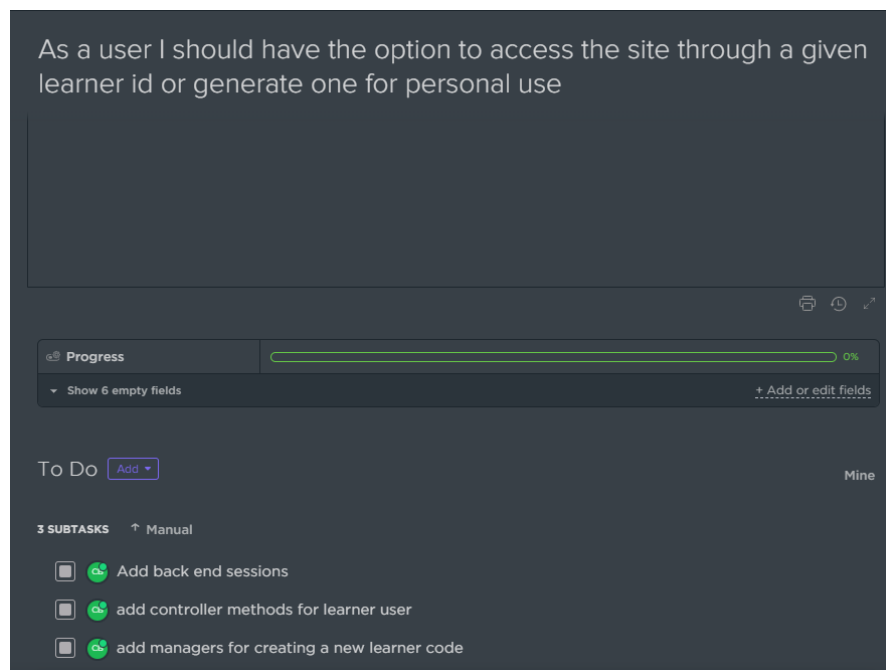
Before starting development, user stories need to be defined. These user stories will be used within the sprint as tasks. They give a brief example of functionality that is required for the system.



A user should be bound to one or more learner codes, each learner code represents either a class or their single session, they are only allowed one single session	CB		-	-	-	-	0%	...
As a teacher I should be able to sign up to the service	CB		-	-	-	-	0%	
As a teacher I should be able to create a class	CB		-	-	-	-	0%	
As a teacher I should be able to generate learner codes for my class	CB		-	-	-	-	0%	
As a user I should be able to customise the speed text appears on the screen for me to read	CB		-	-	-	-	0%	
As a teacher I should be able to sign out of the service	CB		-	-	-	-	0%	
As a learner I should have the option to skip a tutorial	CB		-	-	-	-	0%	
If I know how to use a certain feature/ do a certain task	CB		-	-	-	-	0%	
As a learner, I should be able to interact with a ecommerce simulation	CB		-	-	-	-	0%	
As a user I should be able to customise the size of the text on the screen	CB		-	-	-	-	0%	
Grow up boxes require double click to activate on click event	CB		-	-	-	-	0%	
The service should have a worker that is able to apply itself to any tutorial window and show the user how to complete the tasks step by step	CB		-	-	-	-	0%	

Figure 3.4.1: User Stories created and added to Click Up.

Figure 3.4.1 shows a small selection of the user stories created on the Click Up sprint board. As the user stories are quite vague in terms of technical requirement, they are then broken down further.



As a user I should have the option to access the site through a given learner id or generate one for personal use

Progress: 0%

Show 6 empty fields + Add or edit fields

To Do Add ▾ Mine

3 SUBTASKS ↑ Manual

- ☐ Add back end sessions
- ☐ add controller methods for learner user
- ☐ add managers for creating a new learner code

Figure 3.4.2: User Story broken into further technical detail.

Figure 3.4.2 demonstrates a user story getting broken down into technical tasks. In this instance those tasks discuss the three parts of code that will need to be written for this user story to be satisfied.

3.6 Design Specification

3.6.1 User Interface Wireframes

The main user experience that is important is the learner one. There are two primary areas the learner and teacher will interact with that need to be designed correctly.

For the learners, an abstract layout for an interactive course needs to be designed. This is an area where the service simulation can sit, alongside the tutorial, task list and any other contextually relevant items.

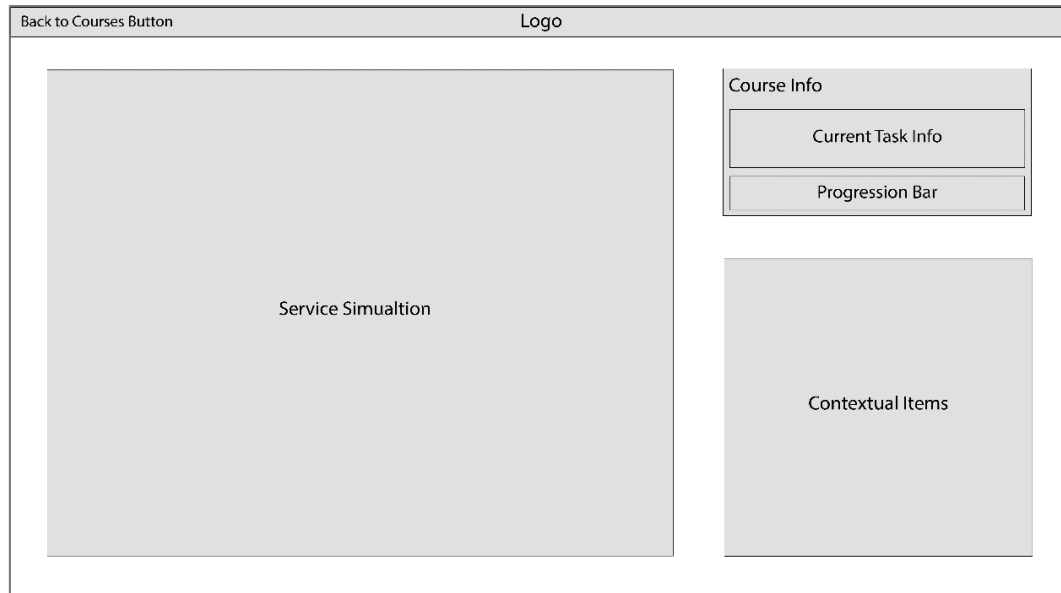


Figure 3.5.1: Learner Interactive Course Wireframe

Figure 3.5.1 shows the interactive course wireframe that is used by a learner. The service simulation area is the section where the ecommerce simulation or payment form simulation will sit. The contextual items section is for any items that are relevant to the simulation. For example, to complete the payment form simulation, the user must copy payment information from a bank card. In that scenario, the bank card would be drawn in the contextual items section. The course info will have details such as the progression the learner is making through the course and the tasks they must complete.

For the teachers, an area where they can manage their classrooms and their learners is required.

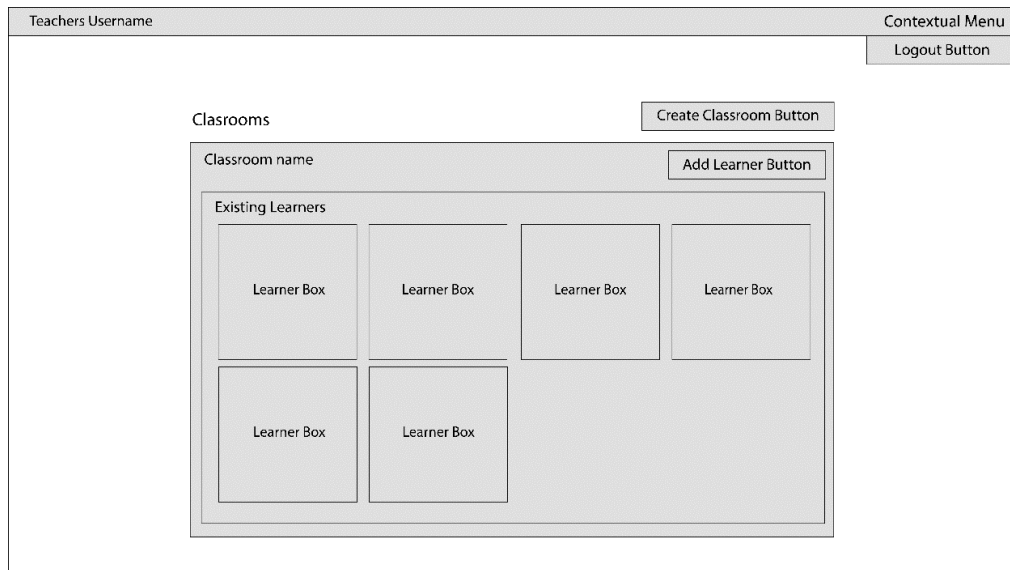


Figure 3.5.2: Teacher Classroom Management Wireframe

Figure 3.5.2 shows the teachers' management area for handling learners and classrooms. A teacher can see which learners are in what classroom and can add learners to them. Here they are also able to create additional classrooms. The learner box shows the learners details, their name, and learner code.

3.6.2 Application Architecture

As mentioned previously, the application was split up into three main areas: the front-end, back end and database. Each of the areas interact with one another for the application to fully function. The application architecture demonstrates how this is possible.

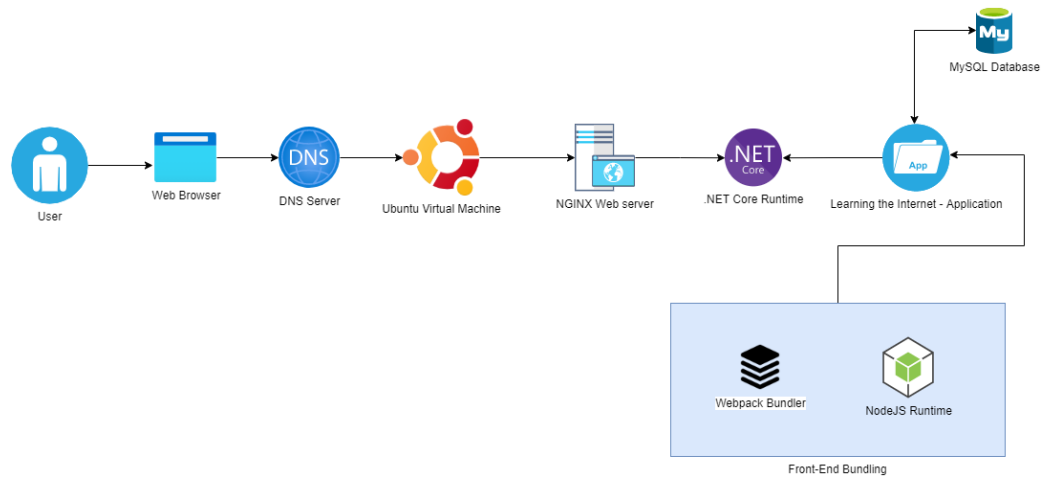


Figure 3.3: System Architecture

Figure 3.3 is the final design for the applications architecture. It demonstrates in a very linear pattern how each element in the system will interact with one another. The front-end gets bundled up into one main script file with a resources folder that stores images and fonts. This is then served by the back end of the application. The back end of the application is the only part of the architecture that handles writing and reading to the database. This all runs on the Ubuntu operating system, that uses a Nginx web server to direct http requests to the .NET Core runtime. This will be detailed further within the deployment.

4 Development

4.1 Development Setup

4.1.1 Project Structure

An organised modular code structure is far easier to maintain as components are easier to substitute, remove, and test than components with mixed functionalities (Visser, 2016).

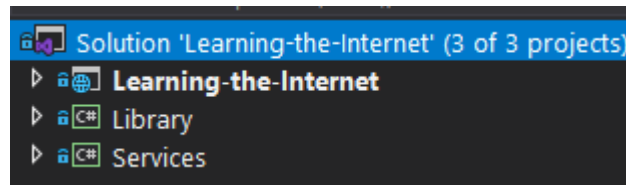


Figure 4.1.1: Solution Structure

Figure 4.1.1 shows the project's structure in visual studio. The first part of the back end is the 'Learning-the-internet' solution. The part contains the externally facing functionality, it stores the application's views and controllers. This is the part that serves the content and functionality to the user. Once the front-end is bundled up it will be served from here. The second solution is the 'Library'. This is where the entities of the system are stored. There is no form of functionality within this solution, it is simply referenced by the other two. The 'Services' folder is where the managers sit. The managers are the part of the application that implement functionality, for example, interacting with the database or calculating results. Most entities from the 'Library' folder have a subsequent manager that handles its interactions within the application.

4.1.2 Front-end Configuration

The front-end is bundled together through the help of the NodeJS runtime and Webpack. Webpack allows all the TypeScript, SCSS and additional libraries to be bundled into one JavaScript file.

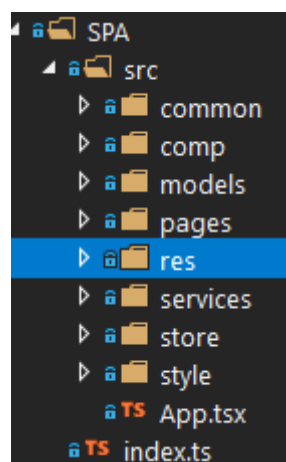


Figure 4.1.2: Single page application precompiled file structure.

Figure 4.1.2 shows the front-end project structure. Inside of the comp folder is all the react components. These are building blocks that help put an application page together. They are put together within the pages folder.

There are multiple JavaScript libraries that are being used within this project. They are all identified within **Figure 4.1.3**. Most of the libraries provide type definitions and webpack loaders. Type definitions are for helping TypeScript recognises vanilla JavaScript modules and Webpack loaders are to help with bundling non-JavaScript file types.

The front-end is also using the React Redux library which helps manage global state within the front-end. For example, this could make sure the users first name is accessible through all components. The global state management is handled through items in the store folder.

The style folder is for SCSS files. The common folder is for common functions that are used across the app. The model's folder is for the TypeScript version of the entities that are found in the 'Library' solution from **Figure 4.1.1**.

```
"devDependencies": {
  "@babel/core": "^7.6.4",
  "@babel/preset-env": "^7.6.3",
  "@babel/preset-react": "^7.6.3",
  "@babel/preset-typescript": "^7.6.0",
  "@types/animejs": "^3.1.2",
  "@types/react": "^16.9.9",
  "@types/react-copy-to-clipboard": "^5.0.0",
  "@types/react-dom": "^16.9.2",
  "@types/react-redux": "^7.1.1",
  "@types/react-router-dom": "^5.1.0",
  "@types/react-typist": "^2.0.1",
  "@types/webpack-env": "^1.14.1",
  "babel-loader": "^8.0.6",
  "copy-webpack-plugin": "5.1.2",
  "css-loader": "^3.2.0",
  "css-modules-typescript-loader": "^3.0.1",
  "file-loader": "^5.0.2",
  "node-sass": "5.0.0",
  "prop-types": "^15.7.2",
  "redux-devtools-extension": "^2.13.8",
  "sass-loader": "10.1.0",
  "source-map-loader": "^0.2.4",
  "style-loader": "^1.0.0",
  "typescript": "^3.6.4",
  "webpack": "^4.41.2",
  "webpack-cli": "4.2.0"
},
"dependencies": {
  "@uifabric/icons": "7.3.0",
  "@uifabric/react-cards": "0.109.2",
  "animejs": "^3.2.1",
  "connected-react-router": "6.6.1",
  "downloadjs": "^1.4.7",
  "framer-motion": "2.9.0",
  "node-gyp": "^3.8.0",
  "office-ui-fabric-react": "^7.53.0",
  "react": "^16.10.2",
  "react-copy-to-clipboard": "^5.0.3",
  "react-dom": "^16.10.2",
  "react-redux": "7.1.3",
  "react-router": "5.1.2",
  "react-router-dom": "5.1.2",
  "react-typist": "^2.0.5",
  "redux": "4.0.4",
  "typewriter-effect": "^2.17.0"
}
```

Figure 4.1.3: Used JavaScript libraries referenced from the Node packages.json.

4.1.3 Database Setup

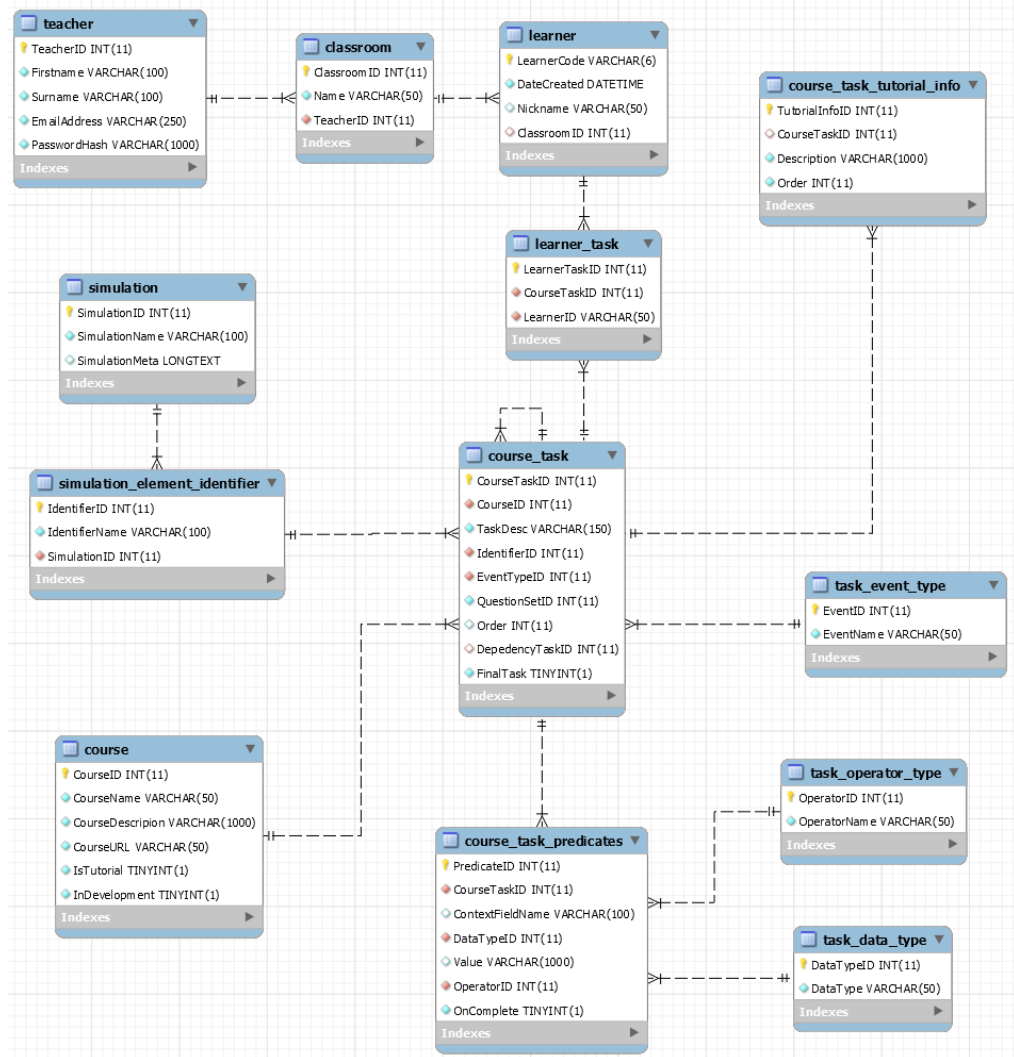


Figure 4.1.4: Database Entity Relationship Diagram

Figure 4.1.4 shows the database structure for the application. This is first initial design and implementation of the database; it is likely that during further development the database must be changed.

The database integrates with the back end of the application using the Microsoft library Entity Framework. Entity Framework connects the MySQL database and reads the current schema.

```

DbEntities
├── Classroom.cs
├── Course.cs
├── CourseTask.cs
├── CourseTaskPredicate.cs
├── CourseTaskTutorialInfo.cs
├── DatabaseContext.cs
├── Learner.cs
├── LearnerTask.cs
├── QuestionSet.cs
├── Simulation.cs
├── SimulationElementIdentifier.cs
├── TaskDataType.cs
├── TaskEventType.cs
├── TaskOperatorType.cs
├── Teacher.cs
└── User.cs

```

Figure 4.1.5: C# Database entities scaffolded by Entity Framework.

It then scaffolds the tables as entities using C# class files which can be seen in **Figure 4.1.5**. These entities are then used within the application to interact with the database. As Microsoft's normal support is for SQL Server, an additional provider is required to help Entity Framework understand MySQL. This is done through Pomelo's Entity Framework NuGet Package.

4.2 Implementation

For this prototype application the primary focus is for learners to have access to a tutorial and exam for both an ecommerce and payment service. There is the additional need for teacher accounts that provide the learner with a code to login.

4.2.1 Security

The first area of security that needs to be addressed is user accounts. Teachers sign up to the application with an email address and a password. To make sure passwords are stored securely they are hashed.

```
2 references
public string Hash(string value)
{
    var rndSalt = new byte[SaltSize];
    new RNGCryptoServiceProvider().GetBytes(rndSalt);
    var rfc2898 = new Rfc2898DeriveBytes(value, rndSalt, HashIterations);
    byte[] hash = rfc2898.GetBytes(KeySize);
    return $"{Convert.ToBase64String(rndSalt)}|{HashIterations}|{Convert.ToBase64String(hash)}";
}
```

Figure 4.3.1: Hashing functionality

Figure 4.3.1 shows the function that makes sure the passwords are salted and then hashed with the RFC 2898 algorithm. Fortunately, Microsoft provide a cryptography library to help with this.

Teachers and learners should only have access to end points that are relevant to them, therefore, additional security needs to be enforced in the form of permissions.

```
[HttpGet]
[LearnerFilter]
0 references
public async Task<JsonResult> Dashboard()

[HttpPost]
[TeacherFilter]
0 references
public async Task<JsonResult> Dashboard()
```

Figure 4.3.2: Endpoint attribute permission filters.

Every time a user makes a request to the application, it will check for a filter seen in **Figure 4.3.2**. If one is found, the application will then check if the current user has an existing session, if one is found and they are of the correct permission set (teacher or learner) they are able to perform the action. This also means that users that are not logged into the application will have no access.

4.2.2 Simulations

As mentioned within the research, simulations are a key part of the application to ensure learners can experience an online service without having to use a real one. The two primary simulations that are going to be implemented are the ecommerce service and the payment form.

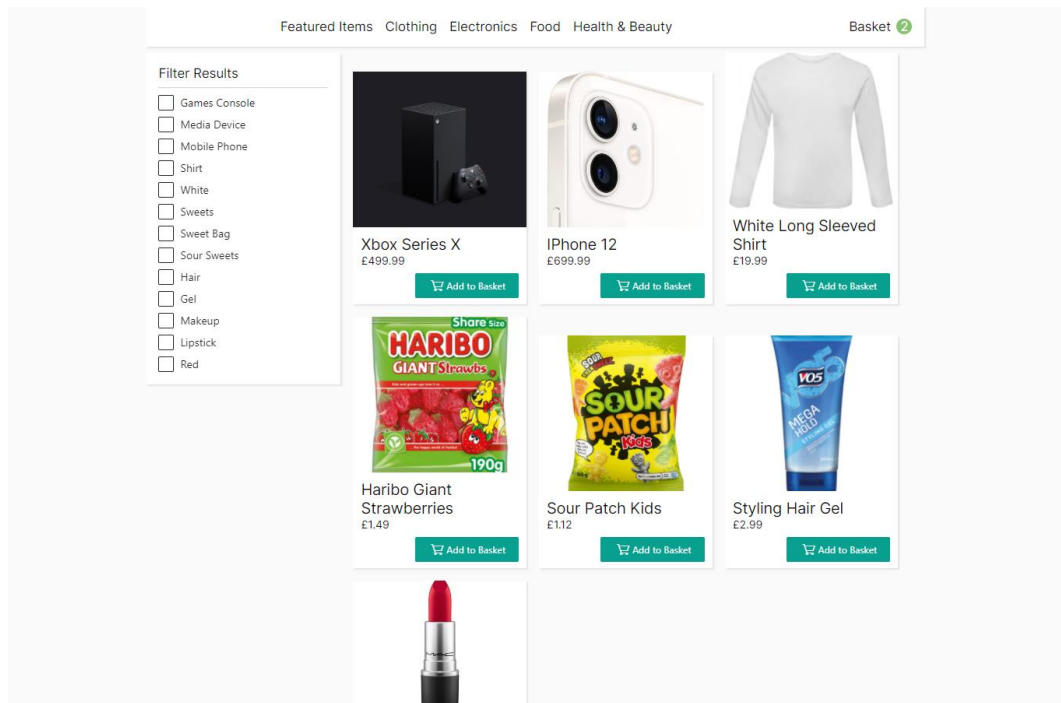


Figure 4.4.1: Ecommerce service simulation.

Figure 4.4.1 shows a screenshot of the featured tab from the ecommerce simulation. The ecommerce simulation is a replica of an online shop. The goal of the simulation is for learners to navigate through the shop, filter for items, and use a shopping basket. Items in the shop must be familiar for the learner, so brand names and common shopping items are present.

A screenshot of a payment form interface. At the top left is a button with a left arrow and the text 'Go Back to Billing Information'. Below this is the section header 'Payment Details'. The form contains several input fields: 'Name on Card *' (a single-line text box), 'Card Number *' (a single-line text box with a dashed line indicating a long number), 'Expiry Date *' (a two-part date box with slashes), and 'CVV/CVC Number *' (a three-digit text box). At the bottom of the form is a green button labeled 'Complete Payment'.

Figure 4.4.2: Payment form simulation.

Figure 4.4.2 shows a section of the payment form simulation where the learner must fill in bank card details. This may seem simple to the normal internet user, however, to a new learner, handling banking information is an intimidating process. This is a scenario where there are additional contextual items that need to be present.

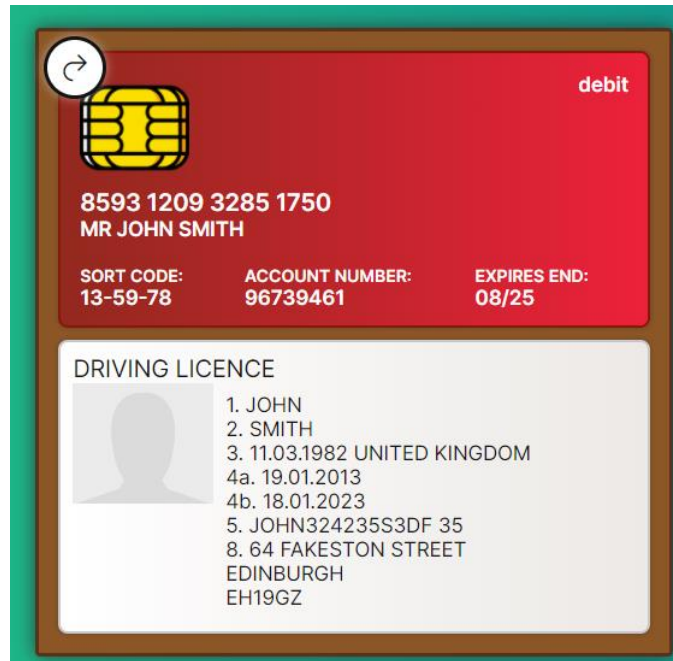


Figure 4.4.3: Payment form simulation context items.

There are external items that a user would be expected to interact with when using an online service. The learner should not be interacting with anything outside of the application when learning so the simulation must account for contextually relevant items. Therefore, the payment form simulation contains a bank card and a form of identification (**Figure 4.4.3**).

4.2.3 Course and Simulation Integration

Courses have multiple tasks that a user must complete. These tasks vary depending on the type of course and simulation. The user must figure out how to accomplish it by interacting with the simulation.

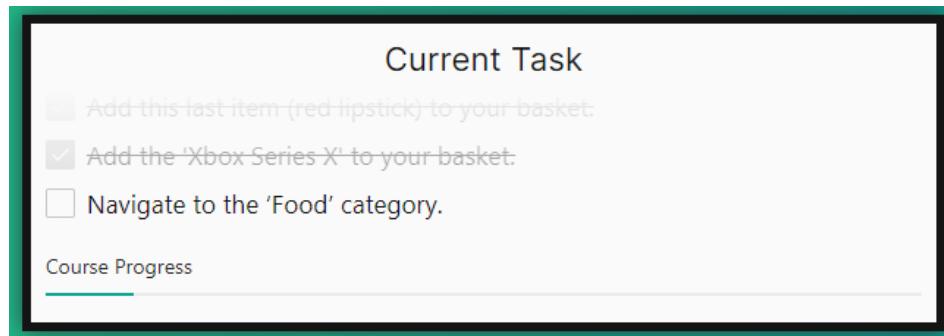


Figure 4.5.1: Current task interface taken from online shopping course.

To integrate course tasks and the simulation together, the application needs to know which parts of the simulation the learner is interacting with. To do this requires an element that detects user interaction, which will wrap itself around elements inside of the simulation.



Figure 4.5.2: Ecommerce Add to basket element.

```
<SimulateElement Identifier={EcoSimIdentifier.ADD_TO_BASKET} ContextItem={m} key={m.itemID}>
  <PrimaryButton
    className={style['add-to-basket']}
    iconProps={{ iconName: 'ShoppingCart' }}
    onClick={() => this.props.addToBasket(m)}>
    <T1>Add to Basket</T1>
  </PrimaryButton>
</SimulateElement>
```

Figure 4.5.3: React simulation element wrapper.

Figure 4.5.2 shows the 'Add to Basket' button element from the ecommerce simulation and **Figure 4.5.3** shows how it is wrapped with the 'SimulationElement' component. It still contains its functionality, in addition, the wrapper is aware of interactions a user has with it.

A 'SimulationElement' will associate itself with a course task using predicates. Predicates are a list of requirements that the application uses to bind tasks with elements on the simulation, like an 'Add to Basket' button. For example, the 'Add to Basket' button has properties that tell the simulation which shopping item it will add to the basket. If the predicate requirements are to find a button for a specific item getting added to the basket, then the application will bind that task to the element.

PredicateID	CourseTaskID	ContextFieldName	DataTypeID	Value	OperatorID	OnComplete
21	35	itemID	2	19	1	0

Figure 4.5.4

Predicates are stored within the database, this way they have a relational link with a task. **Figure 4.5.4** shows an example of a single predicate. Predicates contain which property the value can be found on, the data type of the value, and the value expected. The application then builds a custom true or false expression based on a given list of predicates. The predicate outcome of **Figure 4.5.4** is looking at an object property named 'itemID' and expecting an integer value of 19. This is because the id for red lipstick is 19 and the shop items id can be found on the 'itemID' property.

```
function SatisfiesPredicates(taskPredicates: CourseTaskPredicate[], contextItem: any): boolean {
  let predicateResults: boolean[] = taskPredicates.map(pred => {
    // For primitive context item types
    if (pred.contextFieldName == undefined || pred.contextFieldName.length === 0)
      return contextItem === ParsePredicateDataType(pred.value, pred.dataType);

    // For object context item types
    const contextValue = pred.contextFieldName.split(".").reduce((n, c) => n[c], contextItem);
    if (contextValue === undefined)
      return false;

    const predicateValue = ParsePredicateDataType(pred.value, pred.dataType);
    return GetPredicateOperatorResult(contextValue, pred.operatorName, predicateValue);
  });

  return predicateResults.every(e => e);
}

// TODO: Turn the operator property into a enum
function GetPredicateOperatorResult(contextValue: any, operator: string, predicateValue: any) {
  switch (operator) {
    case "EQUALS":
      return contextValue === predicateValue;
    case "NOT_EQUALS":
      return contextValue !== predicateValue;
    case "LARGER_THAN":
      return contextValue > predicateValue;
    case "LESS_THAN":
      return contextValue < predicateValue;
    case "INCLUDES":
      return contextValue.includes(predicateValue);
    default:
      console.log("Task Error, predicate had an unknown operator, so false was returned as default");
      return false;
  }
}

// TODO: Maybe create a data type enum
function ParsePredicateDataType(predicateValue: any, dataType: string) {
  switch (dataType) {
    case "int":
      return parseInt(predicateValue);
    case "float":
      return parseFloat(predicateValue);
    case "boolean":
      return predicateValue === "true";
    case "array.boolean":
    case "array.int":
    case "array.string":
    case "array.float":
      return JSON.parse(predicateValue);
    default:
      return predicateValue;
  }
}
```

Figure 4.5.5: JavaScript predicate expression builder code.

Figure 4.5.5 demonstrates how the predicate expression is built. It means that the 'SimulationElement' wrapper can be applied for a variety of different course simulations. The ability to generate true or false expressions dynamically provides a very abstract foundation. It means the application can easily accommodate for new tasks by adding them to the database instead of manually coding the requirements needed to complete it.

4.2.4 Tutorial Overlay

Half of the courses available to the learner are tutorials. Therefore, there is a requirement for showing the user what to do in a step-by-step manner.

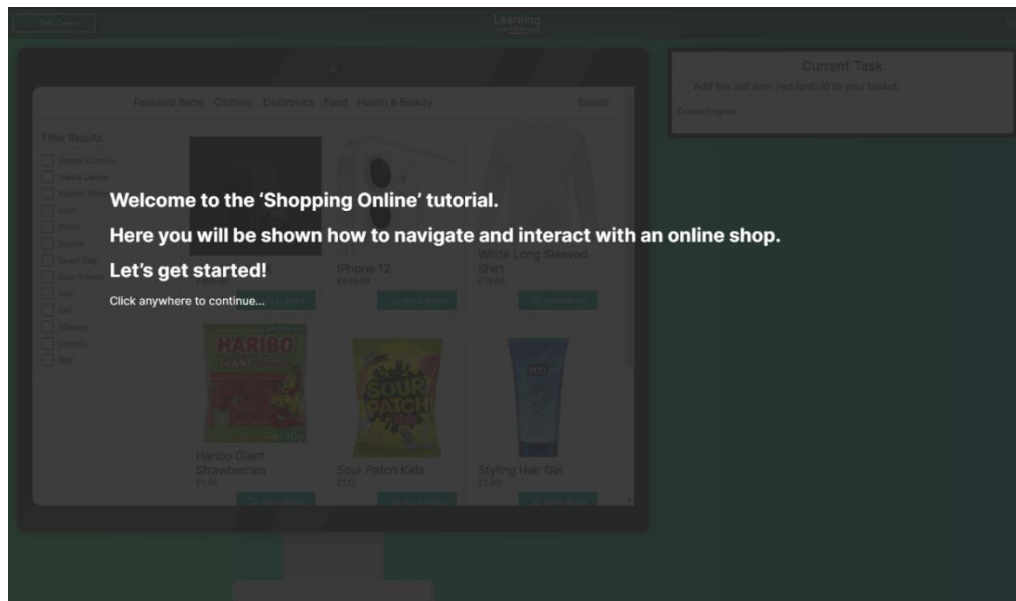


Figure 4.6.1: Course tutorial overlay

Figure 4.6.1 shows the tutorial overlay that is triggered after completing a task when the learner is on a tutorial course. The overlay acts similarly to a slide show, where there are multiple slides of information. This is to avoid presenting a lot of information at once.

Like Kahoots' style of content delivery, the text is animated with the typewriter-effect JavaScript library, which causes the text to enter as if it were being typed out by a human. This is to make the user feel like they are going along with the flow of the application, instead of having pause and read a block of text.

4.2.5 Teaching Control Panel

Teachers are the only users who are required to sign up to the application. The teacher control panel is where the learner codes are generated which learners can use to quickly access the application.

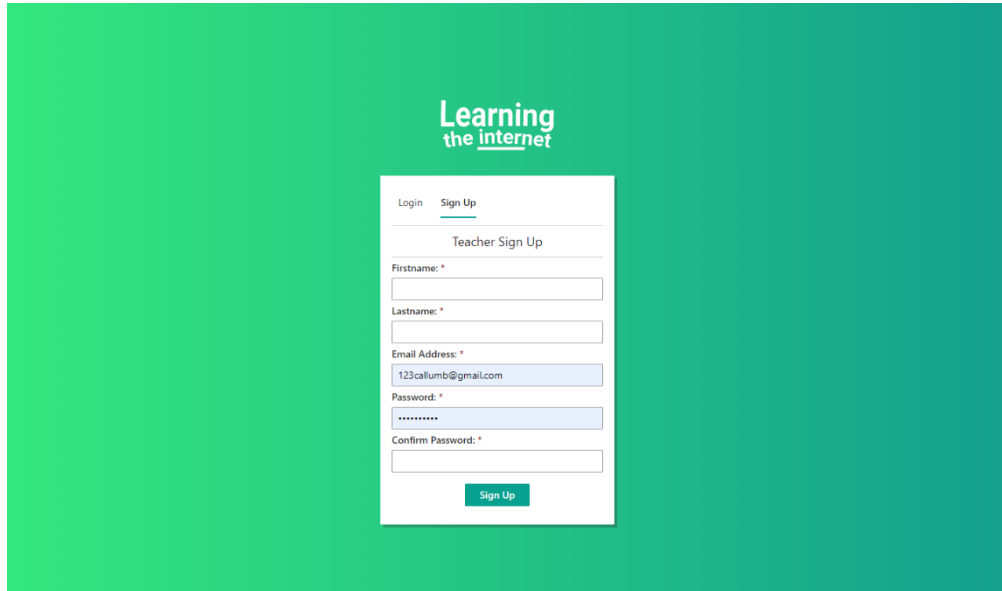


Figure 4.7.1: Teacher sign up page.

Figure 4.7.1 shows the teacher login page which is currently focused on the sign-up tab. Teachers must sign up with an email address and a password.

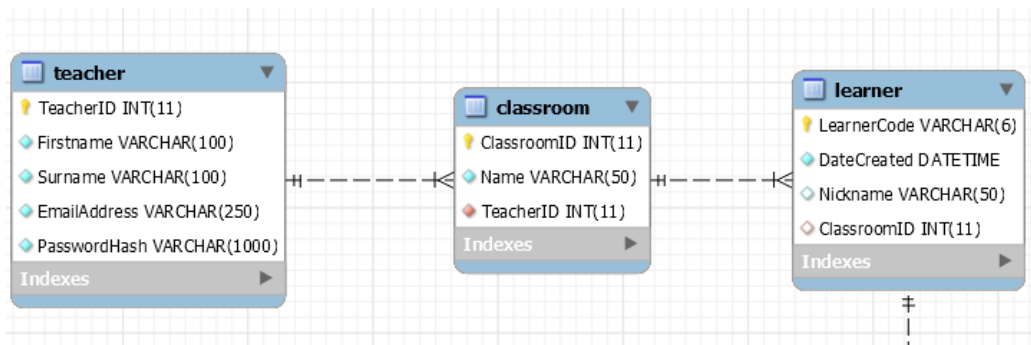


Figure 4.7.2: Teacher learner entity relationship diagram

Figure 4.7.2 shows the relationship between a teacher, classroom, and their learners. The teacher can create as many classrooms as they like and add as many learners to that classroom as they want. Learners that access the application themselves without a teacher being present are not associated with a classroom.

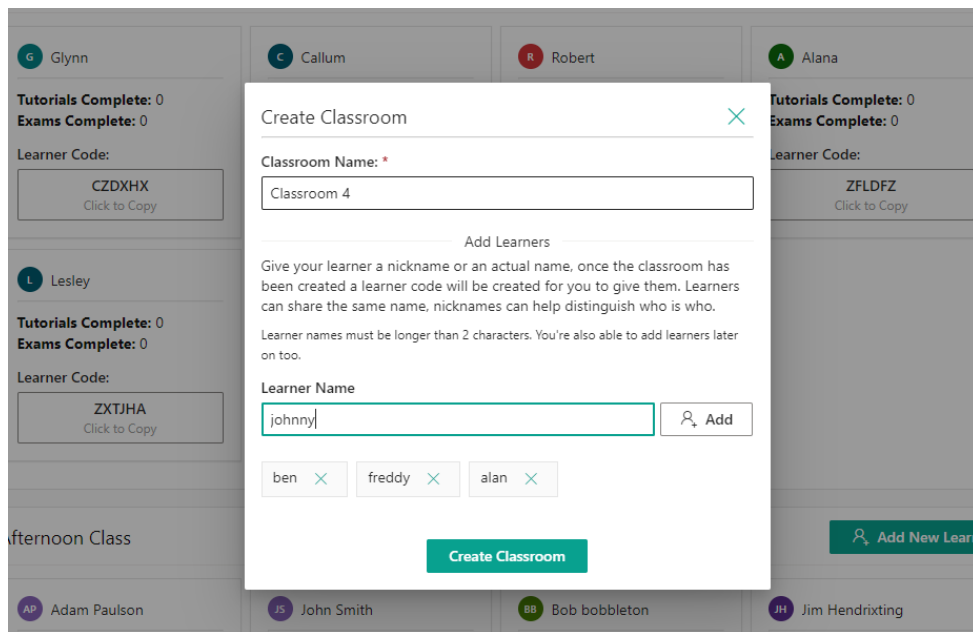


Figure 4.7.3: Classroom creation modal within teacher control panel

Figure 4.7.3 shows the classroom creation process where the teacher can set a classroom name and add learners. Learners only require a nickname to be created. The full legal name is not a requirement as it needs to be anonymous because learners are not signing up themselves.

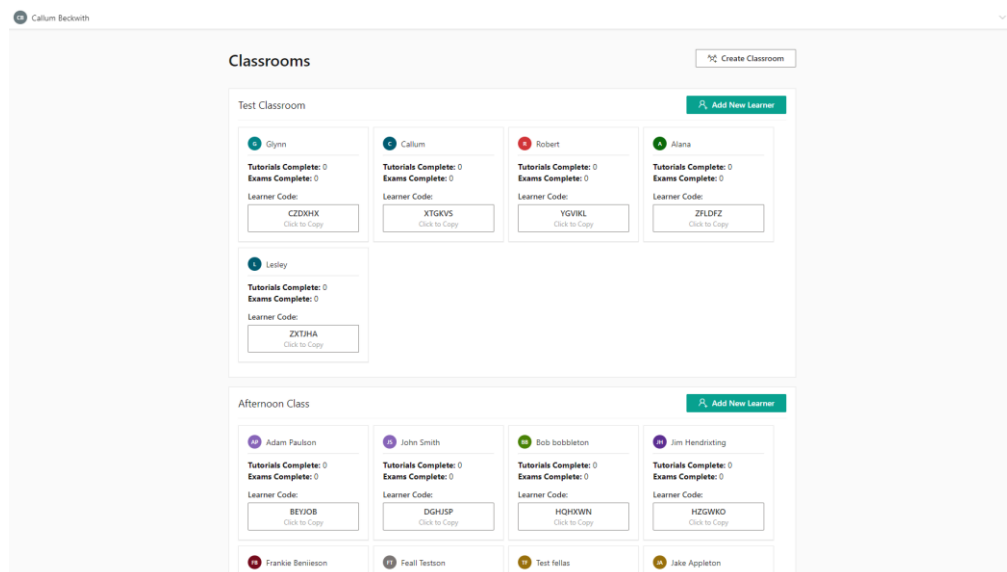


Figure 4.7.4: Teacher control panel with active classrooms.

Figure 4.7.4 shows the teacher control panel when there are multiple active classrooms and learners. Learner codes are displayed in the form of a button and can be quickly copied by clicking on them. Here the teacher can see how many tutorials and how many exams the learner has completed.

The teacher control panel is not as colourful or animated as the learning section of the application. This is because a teacher will be expected to already have a sense of navigating through an online application, so it is not necessary to inform them about every bit of functionality.

4.2.6 User Interfaces

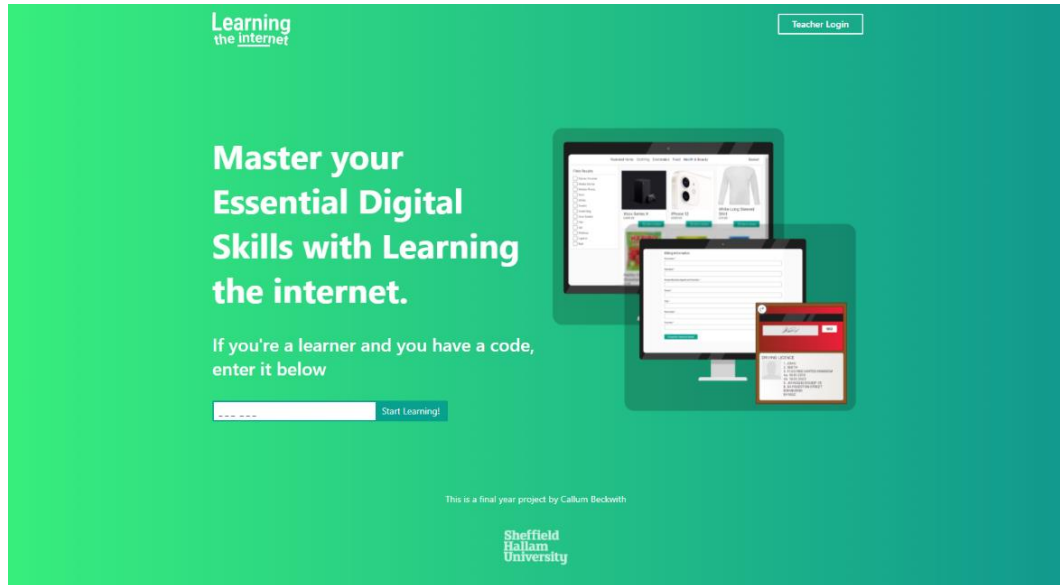


Figure 4.8.1: Learning the internet, home screen.

Figure 4.8.1 shows the home screen for the applications. The learner code box is present here, so the learner does not have to click any further to access the application. The teacher can access their functionality through clicking the teacher login button in the top right-hand corner.

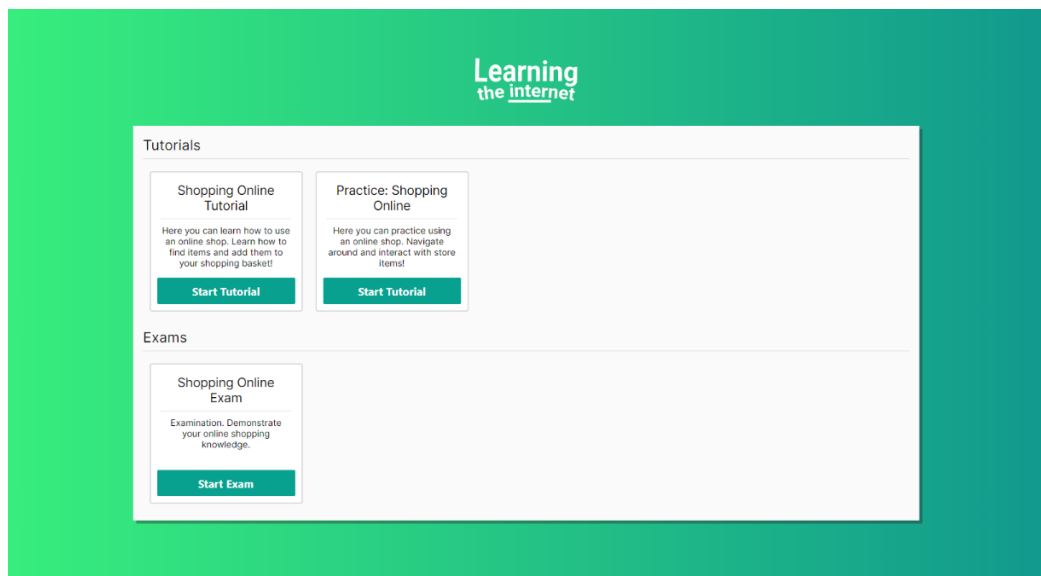


Figure 4.8.2: Learner home page – available courses.

Figure 4.8.2 shows the learner home page. This is where the learner has access to courses. Courses are either in the form of an exam or a tutorial.

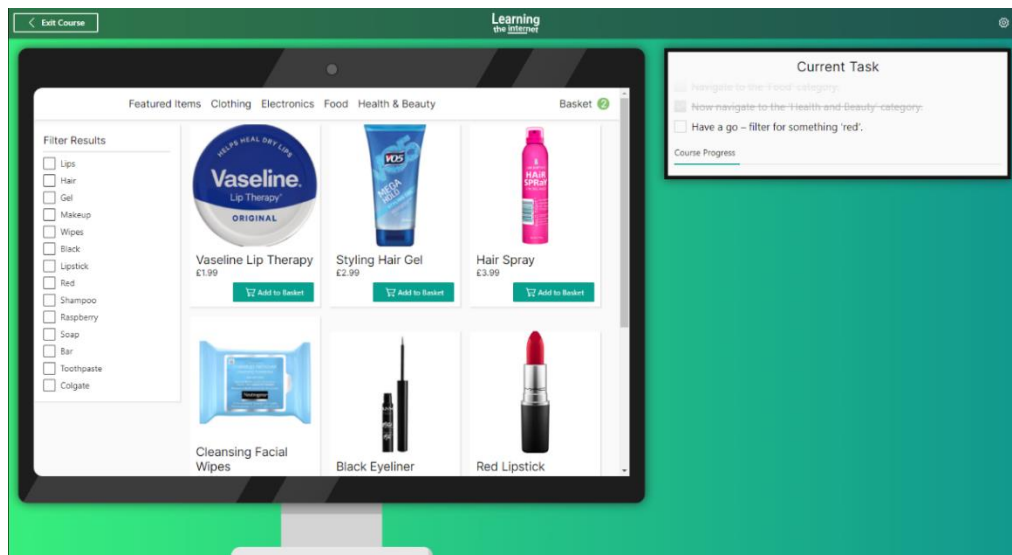


Figure 4.8.3: Ecommerce course interface.

Figure 4.8.3 shows the final implementation of an ecommerce course. The simulated services sit inside of a computer to give a sense of familiarity and to reiterate the point that it is not a real service.

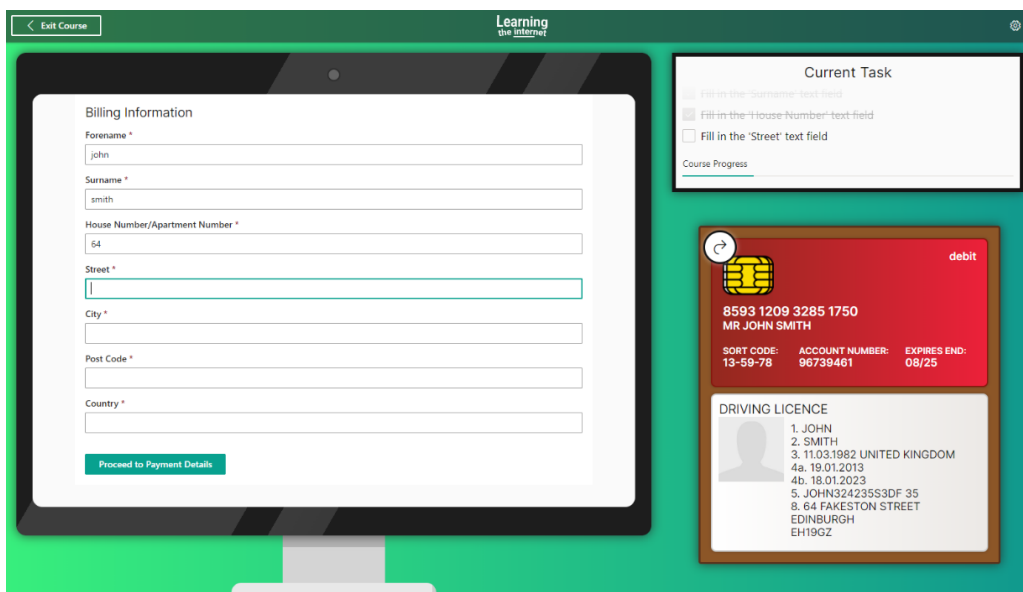


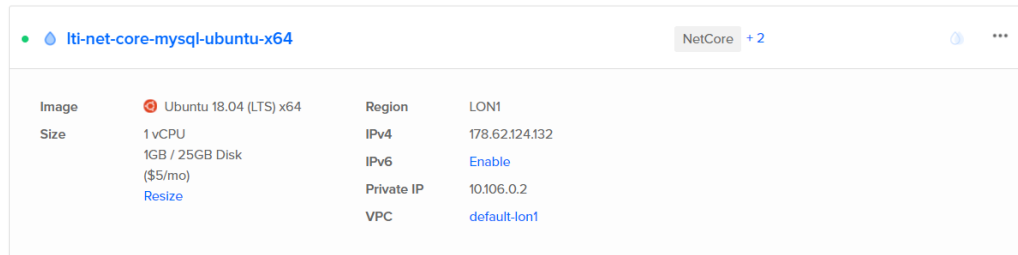
Figure 4.8.4: Payment course interface.

Using the same styling approach as the ecommerce course, **Figure 4.8.4** shows the payment form course. Unlike the ecommerce course, this course has additional items that are relevant to complete the tasks. These items sit underneath the task list.

4.3 Prototype Deployment

4.3.1 Digital Ocean

Digital Ocean provides the use of droplets. Droplets are virtual machines that can be setup using a specified operating system and hardware. The better the hardware, the higher the monthly cost of using it. Instead of using Digital Ocean's dedicated databases, using a virtual machine running a database will be the most cost-effective approach.



The screenshot shows the configuration for a Digital Ocean droplet named 'liti-net-core-mysql-ubuntu-x64'. The configuration is as follows:

Property	Value
Image	Ubuntu 18.04 (LTS) x64
Size	1 vCPU 1GB / 25GB Disk (\$5/mo) Resize
Region	LON1
IPv4	178.62.124.132
IPv6	Enable
Private IP	10.106.0.2
VPC	default-lon1

Figure 4.9.1: Digital Ocean Ubuntu virtual machine droplet.

Figure 4.9.1 shows an overview of the virtual machine the project is using. The amount of processing required by the virtual machine will be very little, so the base hardware specifications have been used. The virtual machine runs Ubuntu which is well supported as the project only uses cross-platform technology.

DNS records

Type	Hostname	Value	TTL (seconds)	
A	www.learning-the-internet.co.uk	directs to 178.62.124.132	3600	More ▾
A	*.learning-the-internet.co.uk	directs to 178.62.124.132	3600	More ▾
A	learning-the-internet.co.uk	directs to 178.62.124.132	3600	More ▾
NS	learning-the-internet.co.uk	directs to ns3.digitalocean.com.	1800	More ▾
NS	learning-the-internet.co.uk	directs to ns1.digitalocean.com.	1800	More ▾
NS	learning-the-internet.co.uk	directs to ns2.digitalocean.com.	1800	More ▾

Figure 4.9.2: DNS Configuration to point to droplet.

A domain name also needs to be bought as users cannot be expected to connect to IP address in their browsers. These are inexperienced users and entering a string of numbers is only going to add unnecessary confusion. **Figure 4.9.2** shows the linking of the purchased domain name “learning-the-internet.co.uk” with Digital Oceans domain name servers.

Figure 4.9.4: .NET Core runtime of the application running as a Ubuntu service.

```

main@ubuntu-s-1vcpu-1gb-lon1-01: /etc/nginx
GNU nano 2.9.3 sites-available/learning-the-internet.co.uk

server {

    server_name learning-the-internet.co.uk www.learning-the-internet.co.uk;

    location / {
        proxy_pass http://localhost:5000;
        proxy_http_version 1.1;
        proxy_set_header Upgrade $http_upgrade;
        proxy_set_header Connection keep-alive;
        proxy_set_header Host $host;
        proxy_cache_bypass $http_upgrade;
        proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
        proxy_set_header X-Forwarded-Proto $scheme;
    }

    listen [::]:443 ssl ipv6only=on; # managed by Certbot
    listen 443 ssl; # managed by Certbot
    ssl_certificate /etc/letsencrypt/live/learning-the-internet.co.uk/fullchain.pem; # managed by Certbot
    ssl_certificate_key /etc/letsencrypt/live/learning-the-internet.co.uk/privkey.pem; # managed by Certbot
    include /etc/letsencrypt/options-ssl-nginx.conf; # managed by Certbot
    ssl_dhparam /etc/letsencrypt/ssl-dhparams.pem; # managed by Certbot

}

server {

    if ($host = www.learning-the-internet.co.uk) {
        return 301 https://$host$request_uri;
    } # managed by Certbot

    if ($host = learning-the-internet.co.uk) {
        return 301 https://$host$request_uri;
    } # managed by Certbot

    listen 80;
    listen [::]:80;

    server_name learning-the-internet.co.uk www.learning-the-internet.co.uk;
    return 404; # managed by Certbot
}

```

Figure 4.9.3: Configuring Nginx to direct address to .NET Core runtime localhost.

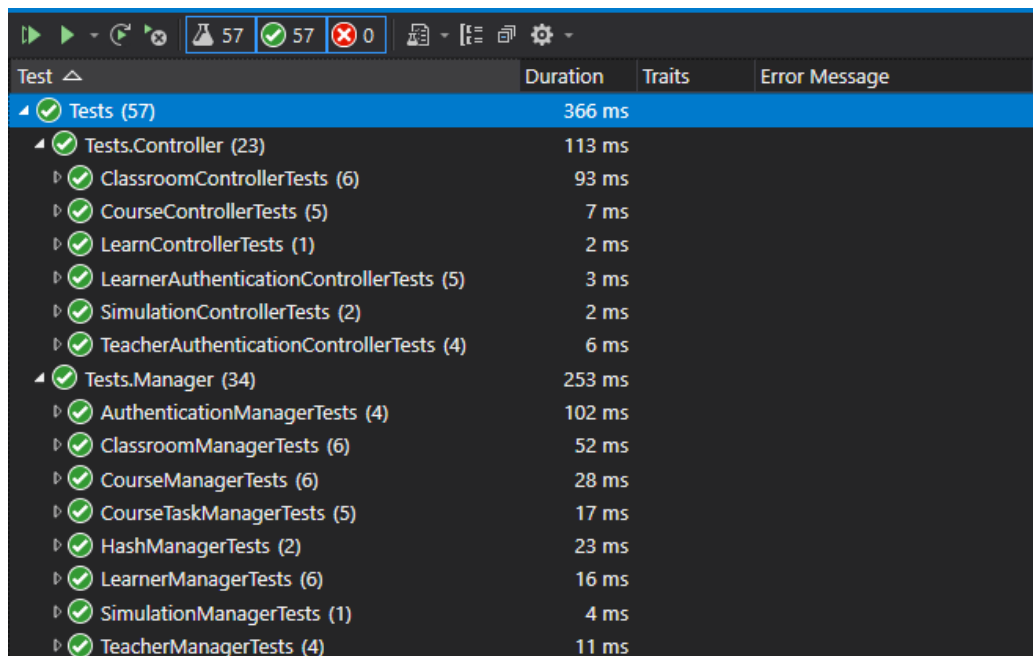
Figure 4.9.3 shows the configuration to get the Nginx server to direct traffic from “learning-the-internet.co.uk” to the port 5001 opened by the .NET Core runtime. The Nginx server is also configured with a package called cert bot, which helps generate a web certificate for secure https connections. The application is accessible at <https://www.learning-the-internet.co.uk>.

5 Testing

Multiple forms of testing were carried out during the development and after the prototype release. This makes sure the software is fit for purpose, as well as identifying defects present in the software (O'Regan G, 2019). Ironing out issues before the prototype is released is also a priority as this project heavily relies on learner users. If a learner user is to experience an error, it is very likely they will be unaware of it and assume they are the ones doing something incorrectly. The following four testing stages were considered including, unit testing, integration testing, system testing and user acceptance testing.

5.1 Unit Testing

Unit testing is a way to make sure that modules within the system satisfy the design. This is done by testing objectives with expected results (O'Regan G, 2019). This is a form of continuous testing that occurred during the development of the application. Microsoft have a testing framework called MS Unit that supports an integrated unit testing experience within visual studio.



Test	Duration	Traits	Error Message
Tests (57)	366 ms		
Tests.Controller (23)	113 ms		
ClassroomControllerTests (6)	93 ms		
CourseControllerTests (5)	7 ms		
LearnControllerTests (1)	2 ms		
LearnerAuthenticationControllerTests (5)	3 ms		
SimulationControllerTests (2)	2 ms		
TeacherAuthenticationControllerTests (4)	6 ms		
Tests.Manager (34)	253 ms		
AuthenticationManagerTests (4)	102 ms		
ClassroomManagerTests (6)	52 ms		
CourseManagerTests (6)	28 ms		
CourseTaskManagerTests (5)	17 ms		
HashManagerTests (2)	23 ms		
LearnerManagerTests (6)	16 ms		
SimulationManagerTests (1)	4 ms		
TeacherManagerTests (4)	11 ms		

Figure 5.2.1: Visual Studio integrated unit test explorer

Figure 5.2.1 shows the unit tests done within the project. 57 tests were successfully completed during and after the development. The unit testing is primarily done on the controller classes and the managers inside of the services solution as most of the logic is within these files. Each function within these files has its own set of tests. The number of tests will depend on the number of outcomes of a function. It is also important not to do too many unit tests as every edge case scenario cannot be accounted for. Writing too many unit tests will lead to other parts of the project losing priority.

```

[TestMethod]
public async Task CompleteTask_TaskDoesNotExist_ThrowsException()
{
    var c = new MockContainer();
    var manager = Manager(c);

    c.GenericQuerier.Setup(s => s.LoadEntity(It.IsAny<Expression<Func<CourseTask, bool>>>()))).Returns(new List<CourseTask>().GetMockQueryable());

    // Act & Assert
    await Assert.ThrowsExceptionAsync<Exception>(() => manager.CompleteTask("FAKE LEARNER CODE", 4));
}

[TestMethod]
public async Task CompleteTask_DependencyIsNotComplete_ReturnsFalse()
{
    var c = new MockContainer();
    var manager = Manager(c);

    c.GenericQuerier.Setup(s => s.LoadEntity(It.IsAny<Expression<Func<CourseTask, bool>>>()))).Returns(new List<CourseTask>()
    {
        new CourseTask()
        {
            DependencyTaskId = 14
        }
    }.GetMockQueryable());
    c.GenericQuerier.Setup(s => s.LoadEntity(It.IsAny<Expression<Func<LearnerTask, bool>>>()))).Returns(new List<LearnerTask>().GetMockQueryable());

    // Act
    var res = await manager.CompleteTask("FAKE LEARNER CODE", 5);

    // Assert
    Assert.IsFalse(res);
}

[TestMethod]
public async Task CompleteTask_DependencyIsComplete_ReturnsTrue()
{
    var c = new MockContainer();
    var manager = Manager(c);

    c.GenericQuerier.Setup(s => s.LoadEntity(It.IsAny<Expression<Func<CourseTask, bool>>>()))).Returns(new List<CourseTask>()
    {
        new CourseTask()
    }
    ).GetMockQueryable());
    c.GenericQuerier.Setup(s => s.LoadEntity(It.IsAny<Expression<Func<LearnerTask, bool>>>()))).Returns(new List<LearnerTask>().GetMockQueryable());

    // Act
    var res = await manager.CompleteTask("FAKE LEARNER CODE", 5);

    // Assert
    Assert.IsTrue(res);
}

```

Figure 5.2.2: Example unit test code within the project

Unit testing is done with the NuGet library Moq. Moq helps mock other function calls that may happen within the method being tested. This way, the unit test is focused directly on one piece of functionality at a time. **Figure 5.2.2** demonstrates the type of unit tests written. For example, in **Figure 5.2.2**, the unit tests are verifying that the course task completing functionality works as intended. It checks to make sure an error will be thrown if the task does not exist, it checks to make sure the task cannot be completed if the dependency task is not complete and makes sure it completes the task if the dependency task is complete.

The unit tests add an additional layer of logic checking that should decrease the number of bugs that appear due to poor coding.

5.2 Integration Testing

Integration testing helps ensure that when modules are brought together to serve a piece of functionality the correct result occurs. During the project this was done every time a task was completed. Integration testing was short, as most functionality within a sprint task was not extremely large. Once there was visible evidence of the functionality working, development on the next sprint item would begin.

5.1 System Testing

System testing is to verify that the implementation is valid with respect to the system requirements (O'Regan G, 2019). A tutor from the computing department of Barnsley Adult Skills and Community Learning was able to play a role in the projects system testing. After each sprint was completed, a new set of functionalities in the application needed testing. The tutor would access the application through the web address and test the new functionality.

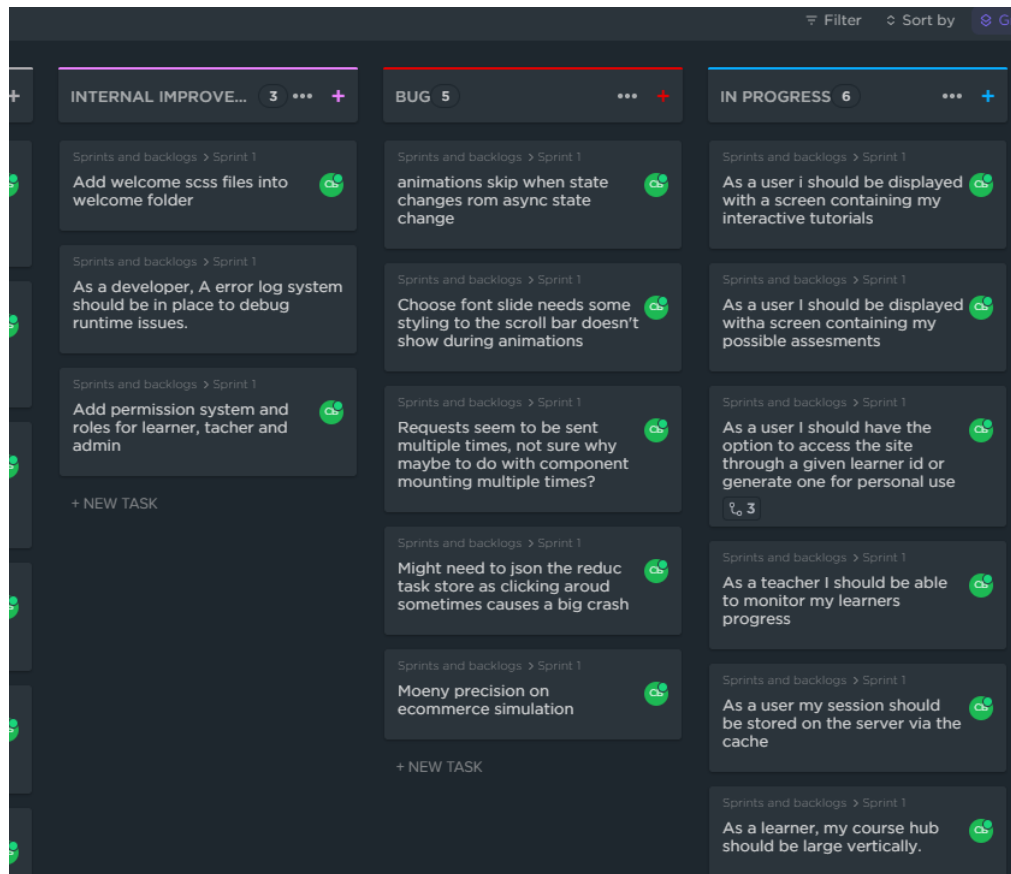


Figure 5.1: Sprint board error tracking.

To understand the system changes the tester had access to the sprint board to see what requirements were added during the current iteration. If a requirement was not correctly satisfied it was noted for the next sprint iteration.

Fortunately, the tester knows the target audience very well. This meant they were able to suggest changes or further improvements that could benefit the learning experience. Once the bugs, improvements and further requirements had been identified, they were added to the sprint board (seen in **Figure 5.1**). It is important to note that if a bug had a substantial impact on the user experience it was prioritized in the next sprint.

5.2 User Acceptance Testing

This form of testing will give the largest indication that the application successfully does what the project set out to achieve. During software testing, user acceptance testing demonstrates that the product satisfies the business requirements and meets the customer expectations. (O'Regan G, 2019).

5.2.1 Testing Audience

Thanks to the help of Barnsley ASCL the user testing group is very well targeted. The users testing the system are learners that are enrolled on the beginner digital skills courses. This means they have little to no experience of using the internet. At this point, it is expected that most bugs that may cause the application to break, have been detected and fixed during the sprints and unit testing. Therefore, it is ideal for the users to treat this as a learning experience, rather than a testing one.

A tutor from Barnsley ASCL will also play a role within testing. Their feedback is likely to be more detailed and directed at the teaching functionality of the application.

5.2.2 Testing Process

Firstly, the tutor from Barnsley ASCL reads the documents associated with GDPR (Appendix C) and the teacher instruction document (Appendix D). This tells the tutor how to sign up to the application and create a classroom for their learners. This document also includes instructions for directing their learners to the tutorials and exams within the application. The learners involved in the testing must also read a GDPR related document (Appendix B). The teacher and the learner have different participation documents as they both have different roles within the application.

To ensure the project adheres to the correct ethics, consent forms must be signed (Appendix E). As the learners have little computing knowledge, having to sign document and then return it electronically not possible. Fortunately, the tutor took the responsibility to sign the consent form on behalf of themselves and the learners.

Once given their code to login to the application, the learner is presented with the course screen. From here they are to complete the 'Shopping Online' Tutorial and the 'Shopping Online' exam.

Finally, once a learner has completed the tutorial and exam, they are asked to fill in two feedback forms. The first feedback form is for general feedback of the application. As most of the questions require written responses, detailed answers were expected. These detailed answers help highlight issues or ideas that may not have been discovered previously.

The second feedback survey (Appendix G) is a standardised questionnaire for the assessment of perceived usability, known as the system usability scale. Learners are given 10 predefined questions that they must chose to answer on scale from 1 to 5. The results given by the learners can be used to calculate a global usability score. This score can be compared with other applications and will be useful to reflect on during the evaluation.

5.2.3 Results

From the general feedback (Appendix H), there were multiple responses that highlighted areas where the application could improve. The remaining responses from the general feedback did not contain any further criticism towards the application and were quite positive.

Do you think the application provides a suitable way to learn for people who are new to the internet?
Yes, but I would have liked the option of a sound tutorial. Thinking of people that aren't already using the internet, there might be some literacy issues that would prevent them from using this application.

Figure 5.3.1: General feedback – Application Suggestions

The idea of introducing sound alongside of the tutorials is a valid idea. This would directly improve the interactivity of the application and information would be delivered straight to the learner without them having to read it on the screen.

Do you think the look and feel of the application are appropriate for its purpose?
I do generally, but thought the text came up a little too quickly and this might be off putting and seem more advanced/complicated that it is. I think a 'back' button to recap on the previous page would help a beginner as well, as when you are first learning something there is a lot to take in and you can forget what is on the previous page/s

Figure 5.3.2: General feedback – Tutorial Suggestions

The project should certainly consider this suggestion (**Figure 5.3.2**). Often, when taking in a lot of information at once it is easy to forget certain parts of it. Adding the ability for learners to replay the last tutorial slide would prevent this issue.

What suggestions would you make to improve the experience you have just had?
Be more specific about what a 'navigation bar' is. People who haven't used the internet before may literally be looking for a bar with navigation written in it. Maybe show a picture with a ring around it and an arrow pointing to it after mentioning it.
Also rather than say click 'checkout', the button actually says 'go to checkout', so I think to avoid confusion with new learners, be very accurate and specific.
If you click on something in error the screen does not do anything. A little pop up/prompt would be useful to acknowledge the user where they have gone wrong and direct them to answer correctly.
As I said above, I think that a sound tutorial would be beneficial to some users and the text displaying a little slower would make it seem less advanced/complicated.

Figure 5.3.3: General feedback – Further Suggestions

In **Figure 5.3.3**, a few issues within the ecommerce tutorial have been highlighted. One part of the text suggests that tutorials should show an image of what the user is expected to do. Currently, the tutorials only display text, and the user must find where in the simulation it refers to. Introducing relevant images with the tutorial text will make tasks clearer.

Figure 5.3.3 also makes note of there being no punishment or error messages shown when the user does something on the simulation that is not related to the current task. Although this is the intention of a simulated learning environment, introducing a feature that detects if a user has strayed too far from the task could be implemented. It would ensure that users who become confused or lost can easily get back on track.

Timestamp	I think th	I found the sys	I thought t	I think that	I w	I found th	I though	I would ima	I found th	I felt ver	I needed	SUS SCORE
2021/04/03 11:22:56 am CET	5	1	5	1	5	1	5	1	4	1		97.5
2021/04/05 2:46:39 pm CET	5	1	5	1	5	1	5	2	5	1		97.5
2021/04/05 3:26:52 pm CET	3	4	3	4	3	3	3	2	5	4		50
2021/04/05 10:22:44 pm CET	5	1	5	1	5	1	5	2	4	1		95
2021/04/07 3:25:31 pm CET	5	1	4	2	4	2	4	1	5	1		87.5
												85.5
Rating	Points											
Strongly Disagree	1											
Disagree	2											
Neutral	3											
Agree	4											
Strongly Agree	5											

Figure 5.3.4: SUS results score calculation.

Figure 5.3.4 shows the results from the SUS feedback form based on values from Appendix I. An average score has been calculated from each of the users' responses and produced a result of 85.5. This is classed as an “Excellent” score, one lower from “Best Imaginable” that requires a minimum score of 90.9 according to research from Lewis (2018). This should mean the application has a high level of usability.

6 Critical Evaluation

6.1 Project Evaluation

6.1.1 Development Evaluation

Development went smoothly, the Agile methodology meant the tasks were getting done in a linear pattern. However, on a few occasions, certain user stories were not defined as well as they could have been. This meant that some tasks would take a significantly longer time than others, and certain tasks could not be started until another part of the system had been implemented. During planning, breaking down the tasks into smaller objectives may have highlighted the level of effort required for each one.

When designing the application, the decision was made to use a relational database. During the implementation, it became clear that parts of the application may have benefited from a NoSQL database. The simulated services, like the ecommerce site, are partially stored within the database. This lets the application create a relationship between a course and a simulation.

A screenshot of a database management tool interface. At the top, it says 'learning_the_internet.simulation: 2 rows total (approximately)'. Below this is a table with three columns: 'SimulationID', 'SimulationName', and 'SimulationMeta'. The first row has '1' in the first column, 'Ecommerce' in the second, and a JSON object in the third. The second row has '2' in the first column, 'Payment' in the second, and another JSON object in the third. The JSON objects contain details about items and wallets. The interface also shows navigation buttons like 'Next', 'Show all', and 'Sorting (1)'.

Figure 6.1.1: Simulation database entity.

As seen in **Figure 6.1.1**, the simulation has a property called 'SimulationMeta'. For this property, it is necessary to use the JSON datatype because each simulation has a variety of different objects. For example, the ecommerce simulation stores the data for each item in the shop, whereas the payment simulation stores the data of a bank card and a driver's license. Most NoSQL databases use JSON data structures that do not require a predefined schema for certain entities. This would be a perfect fit for the simulation entity. As NoSQL databases work better with a JavaScript, this may cause a shift away from using C# for the back end of the application. This would result in a large change to the system architecture.

6.1.2 System Testing Evaluation

Having a tutor from Barnsley ASCL help with the testing integrated extremely well within sprint cycles. However, the testing was very informal as the process lacked structure. The bugs and suggestions were only discussed through conversation. Having a formal document that tracked these issues and suggestions would have decreased the time required for planning the next sprint.

Unit testing proved to be very beneficial for the application and many instances occurred where code needed to be changed to match the intended logic. A better approach with Agile development would have been test driven development (TDD). It would enable an additional level of requirement validation, which is possibly why it has become popular in the Agile world (O'Regan G, 2019).

User acceptance testing was the most constructive form of testing which resulted in valid criticisms and suggestions for the application. Unfortunately, the system was not able to be tested by as many users as first anticipated because Barnsley ASCL do not run during school holidays. As a result, their learners' schedules were quite limited, and most were unable get time to test the application. However, in research of Nielsen

(2001), you gain maximum insight by working with 4-5 users and asking them to think out loud during the test. The general feedback survey (Appendix H) was a form of this and has proven to be true after the testers delivered multiple suggestions that are going to be considered for future development.

6.1.3 Ethics Evaluation

Parts of the project considered the General Data Protection Act (GDPR) regulation. GDPR is a European legal framework that aims to protect user data.

GDPR states that the user should be aware of how their data is being used. A necessary area for using the user data was during the testing user testing stage where their responses are recorded and analysed. The users are given a participation sheet (Appendix B and Appendix C), which specifies what their data will be used for. This should protect the project from breaking the GDPR law.

GDPR also states that data is handled in a way that ensures appropriate security. As highlighted in Appendix B and C to the testing users, any remains of their data within the system will be removed after the project is over. Their data is also stored on a secure database with an application that has multiple security measures in place. This should prevent this GDPR law from being broken.

6.2 Future Development

6.2.1 Feedback Considerations

There are multiple suggestions from section 5.3.3 which would improve the experience when using the application.

A lot of the feedback discussed how tutorials currently work. The initial aim of the tutorial was to effectively inform the user with short, but informative sentences. To avoid the user having to consume a large block of text at once, tutorials containing larger amounts of information are split up into multiple slides. It is evident from the responses noted in section 5.3.3 that only using text is downgrading the way users take in information.

To fix this, it was suggested to have the tutorial slides read out to the user. This way they consume the information through hearing, as well as seeing it on the screen. This will also improve the application for the users that are visually impaired. Additionally, a suggestion to add screenshots alongside the information may make it clearer for the users to understand what the text is referencing.

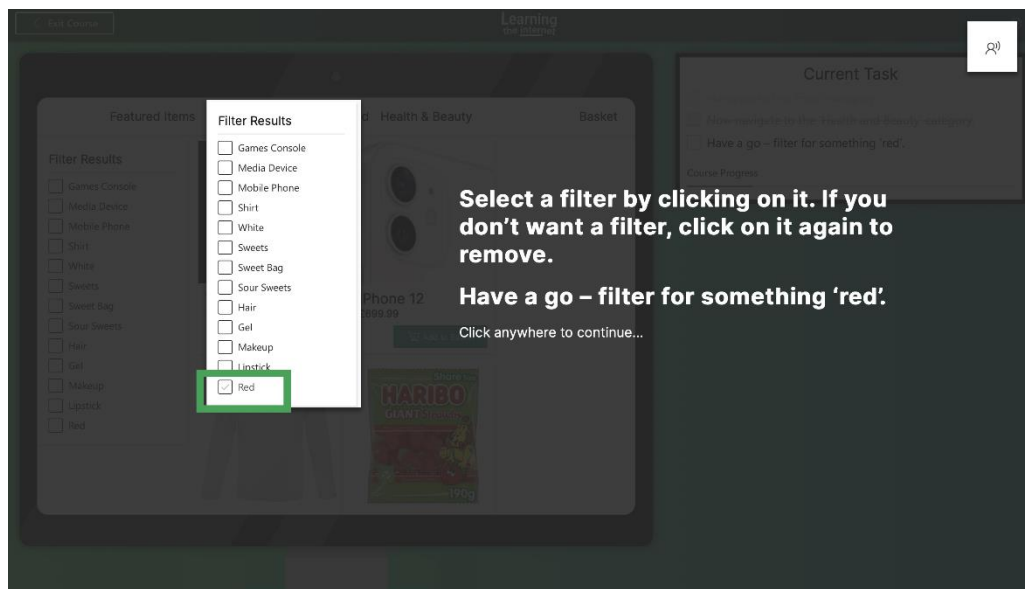


Figure 6.2: Improved Tutorial User Interface

Figure 6.2 shows the changes to the user interface of the tutorial slide if images and a reading toggle were to be added.

It should be considered that adding spoken slides to the application may become problematic, as existing libraries such as Talkify (Hagsten, 2021), provide a very robotic voice. Having an actual human speak the sentences may provide a friendlier environment.

6.2.2 Further Course Development

The project aimed to tackle a portion of the transacting skillset from the Essential Digital Skills framework (UK Government, 2019). There are still some remaining skills within the transacting skillset that have not been covered by the application. For example, upload documents and photographs when this is required to complete an online transaction (UK Government, 2019) and set up an account online (UK Government, 2019).

This project has managed to achieve the base infrastructure for virtual and interactive learning. The implementation is rather abstract and is intentionally built in a way where simulations, courses and tutorials can be added. This means that there is potential to add courses that cover the remaining skills from the transacting skillset. It also means that the application can go even further and cover other skillsets from the Essential Digital Skills Framework, like being safe and legal online (UK Government, 2019). This covers skills like recognising spam emails and understanding privacy settings on social media. For example, social media sites and email inboxes can be simulated and then overlaid with tasks and tutorials.

There are plenty of areas within the Essential Digital Skills framework that can be taught virtually, so there is exciting potential for this project to be an extremely valuable online learning resource.

6.3 Project Reflection

The project has covered many technologies that go towards, planning, developing, and deploying an application. One of the core areas for learning during development has been configuring the front-end bundling. It is easier to produce an online application with html, CSS, and JavaScript without added tools. However, going to the extra effort of bundling resulted in a highly maintainable project structure. Learning this knowledge is very suitable for industry as a modular code base is more accommodating for development within a team.

The research and testing stage has highlighted an existing percentage of users that lack basic of digital skills. The ability to order items online or transfer money to a friend is mostly taken for granted for a lot of people within the UK (Lloyds Bank, 2020). A piece of knowledge to take away from the project should be that inexperienced users must be considered when developing applications. This means when designing applications, actions and functionality should be noticeably clear. If something is overly complex or could be seen as unfamiliar for most users, help sections should be used.

Deployment of the application is an essential stage that all development teams will have to do. Planning and decision making must be done when configuring the production environment for the application. During the project deployment, the necessary areas were carefully studied, and the application was successfully launched into production. This is a useful skill to gain that will certainly come up whilst working in industry.

6.4 Final Thoughts

The purpose of this project was to provide virtual learning resource for the UK Governments Essential Digital Skills framework. To do this, an online application was developed that aimed to teach users the transacting skillset. The application does this by simulating online services and then walking the user through the functionality.

Researching pre-existing online learning resources really helped the way the application delivered information. Additionally, researching websites that approach content delivery with animations, such as Kahoot, was beneficial for learning how to grab the user's attention within the application.

The critical analysis on existing development methodologies was a crucial step that enabled a structured workflow that incorporated testing. This meant development accounted for changing requirements and bug fixes so that the final deliverable was usable and well-tested.

The design stage of the project focused on the systems architecture. A considerable decision here was choosing the most suitable front-end bundling tools and JavaScript libraries. As mentioned previously, adding bundling to the project kept an organised file structure. JavaScript modules, such as component libraries, allowed functionality to be added that would have otherwise taken a significant of time to implement from scratch. Planning out the architecture to use cross-platform tools also proved to be beneficial when it came to deploying the application to a server.

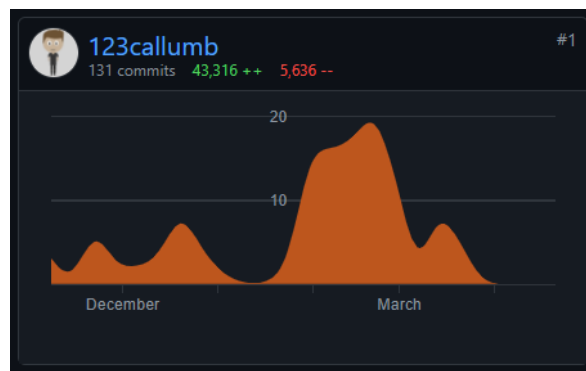


Figure 6.4.1: GitHub repository insights (Nov 8, 2020 – Apr 10, 2021).

The development stage was rather extensive and towards the end of the project the code base of the application was highly comprehensive. With 132 commits to the GitHub repository and over 43,000 lines of code, it is possible to assume there was an underestimation with the amount of work that needed to be completed within 5 months (November - April). Fortunately, the application design was well thought out and the significant amount of coding required did not impact negatively on the implementation stage.

Testing was an important stage of the project that was done in multiple ways. Unit testing and sprint feedback were both done during the development of the system and contributed to validating functionality and minimising bugs. User testing was the final stage of testing and proved to be a great indicator of the overall usefulness of the application. It resulted in various suggestions that have been considered for future development.

The critical evaluation highlighted areas within the project that had room for improvement. There were suggestions for redesigns of the back-end system architecture which may have been more suitable for the application. It considered the feedback from user testing and proved the usefulness if it were to be implemented. It also verified that any ethical concerns of the project were safe and followed the laws of GDPR.

To conclude, the project went through a multiple process to produce the final deliverable. The result is a well-tested, online learning resource that inexperienced users will benefit from. The application is easy to access and provides a safe and interactive learning environment that aims to teach criteria from the UK Government's Essential Digital Skills framework.

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8 Glossary

Bundle	The bundle is the accumulation of files that make up the front-end of the application as one file. This is a JavaScript file format.
CSS	This is a styling language used to style html documents. CSS is an abbreviation of Cascading Style Sheet.
Course	This is used within the project to refer to a collection of tasks. Once a user has completed a collection of tasks, they have completed a course. Courses are associated with a certain skill for example, a shopping online course.
Elements	Within the project, elements are referred to as components of the application, such as a button or an input field.
Learner	Within the project, a learner is one of two users that interact with the system. The learner is the primary demographic the application aims to teach.
Port	A communication end point associated with an IP address. Within the project it is used when discussing server configuration for deployment.
SQL	Structured query language – programming language designed for managing data held in a relational database.
Simulation	A simulation within the project refers to a fake version of an online service or website. Simulations are designed to act like an online service or website with their real-life functionality.
Task	Within the project, a task refers to an objective a learner must complete. An example would be ‘Press the Add to Basket Button’.
Teacher	A teacher within the system refers to one of the two possible users. Teachers are usually someone with strong digital skills who can assist learners.
URL	Uniform Resource Locator – a reference to a web resource that specifies to location on a compute network.
User	A user of the system is anyone that interacts with the application. This may refer to a teacher, or a learner.
Vanilla JavaScript	Vanilla JavaScript refers to the programming language JavaScript when no additional libraries or frameworks are used.
Virtual machine	An emulation of a computer system that provides functionality and power of a physical computer. Usually lives on a server.

9 Appendices

Appendix A

Project Specification

PROJECT SPECIFICATION - Project (Technical Computing) 2020/21

Student:	Callum Beckwith (26023006)
Date:	12th October 2020
Supervisor:	Michael Marriott
Degree Course:	Computer Science
Title of Project:	Application to educate those who are unfamiliar with handling sensitive information online

Elaboration

Using money for the exchange of goods and services online is a modern convenience for most. Unfortunately, there is still a large minority of people who lack fundamental computer skills. As a result, online services like e-commerce sites are difficult for these users to understand and operate. This can leave many people feeling socially excluded from the modern world. The goal of this project is to educate those who are unfamiliar or fearful about using online services that require the use of sensitive information. My solution is to produce a secure online application that simulates common procedures a user is expected to go through on sites where sensitive information is required. The application will function with two core users; a teacher and a learner. The final result will allow the learner to visit any trusted e-commerce website and confidently handle private information. Through the help of Barnsley Adult Skills Community Learning I will be able to demonstrate and conclude the usefulness of the deliverable.

Project Aims

Identify common procedures users will experience when handling their sensitive information online.
Identify development frameworks and libraries that will help create a realistic and learner friendly experience.
Identify software and methods that ensure all data collected by the solution is relevant and secure.
Identify the most appropriate approaches for educating users through online applications.
Use an agile development approach by making use of the resources available.
Develop a back-end system that supports storing and distributing the application data.
Develop a front-end single page application that simulates experiences where the user must deal with sensitive information.
Develop a teacher and learner based environment that will allow learners to access the application with minimal computing knowledge.
Conclude, when done correctly, if an online educational tool can be utilised effectively to reduce the feeling of social exclusion for users who lack fundamental computer skills.

Project deliverable(s)

The core deliverable from this project will be a prototype of a full stack web application that educates users on how to handle sensitive information online.

This will include the following:

- A secure, teacher and learner based user system where learners require little to no skills to access the application.
- Multiple simulated tasks based around users having to handle sensitive information.
- Analytical information for all users to help highlight areas where learners require improvement.

Action plan

Task	Deadline Date
Find project supervisor	9 th October 2020
Project specification & ethics form	23 rd October 2020
Background Research <ul style="list-style-type: none">- <i>Target audience.</i>- <i>Existing applications and teaching/learning methods.</i>- <i>Technologies available and required to build all aspects of the deliverable.</i>- <i>Engineering approaches, methodologies, and tools available.</i>	27th November 2020 (Overall) <ul style="list-style-type: none">- <i>31st October 2020</i>- <i>7th November 2020</i>- <i>14th November 2020</i>- <i>21st November 2020</i>
Information review	4 th December 2020
Design stage <ul style="list-style-type: none">- <i>Application architecture structure</i>- <i>Database structure</i>- <i>User experience and interface</i>	21st December 2020 (Overall) <ul style="list-style-type: none">- <i>7th December 2020</i>- <i>14th December 2020</i>- <i>21st December 2020</i>
Development stage <ul style="list-style-type: none">- <i>Database</i>- <i>Application back-end</i>- <i>Application front-end</i>	12th February 2021 <i>(These tasks will be worked on and completed concurrently)</i>
Provisional contents page	19 th February 2021
Prototype testing and collection of evaluable data with learners and teachers from Barnsley Adult Skills Community Learning	1 st March 2021
Project modifications based on testing evaluation	13 th March 2021
Draft critical evaluation	19 th March 2021
Sections of draft report	19 th March 2021
Upload report	15 th April 2021
Demonstration	29 th April 2021

BCS Code of Conduct

I confirm that I have successfully completed the BCS code of conduct on-line test with a mark of 70% or above. This is a condition of completing the Project (Technical Computing) module.

Signature:

A handwritten signature in black ink, appearing to be 'CB' with a flourish.

Publication of Work

I confirm that I understand the "Guidance on Publication Procedures" as described on the Bb site for the module.

Signature:

A handwritten signature in black ink, appearing to be 'CB' with a flourish.

GDPR

I confirm that I will use the "Participant Information Sheet" as a basis for any survey, questionnaire, or participant testing materials. This form is available on the Bb site for the module and as an appendix in the handbook.

Signature:

A handwritten signature in black ink, appearing to be 'CB' with a flourish.

UREC2 RESEARCH ETHICS PROFORMA FOR STUDENTS UNDERTAKING LOW RISK PROJECTS WITH HUMAN PARTICIPANTS

This form is designed to help students and their supervisors to complete an ethical scrutiny of proposed research. The University [Research Ethics Policy](#) should be consulted before completing the form. The initial questions are there to check that completion of the UREC 2 is appropriate for this study. The final responsibility for ensuring that ethical research practices are followed rests with the supervisor for student research.

Note that students and staff are responsible for making suitable arrangements to ensure compliance with the General Data Protection Act (GDPR). This involves informing participants about the legal basis for the research, including a link to the University research data privacy statement and providing details of who to complain to if participants have issues about how their data was handled or how they were treated (full details in module handbooks). In addition the act requires data to be kept securely and the identity of participants to be anonymized. They are also responsible for following SHU guidelines about data encryption and research data management. Information on the [Ethics Website](#)

The form also enables the University and College to keep a record confirming that research conducted has been subjected to ethical scrutiny.

The form may be completed by the student and the supervisor and/or module leader (as applicable). In all cases, it should be counter-signed by the supervisor and/or module leader, and kept as a record showing that ethical scrutiny has occurred. Some courses may require additional scrutiny. Students should retain a copy for inclusion in their research projects, and a copy should be uploaded to the relevant module Blackboard site.

Please note that it may be necessary to conduct a health and safety risk assessment for the proposed research. Further information can be obtained from the College Health and Safety Service.

Checklist Questions to ensure that this is the correct form

1. Health Related Research with the NHS or Her Majesty's Prison and Probation Service (HMPPS) or with participants unable to provide informed consent

Question	Yes/No
1. Does the research involve?	No
• Patients recruited because of their past or present use of the NHS	
• Relatives/carers of patients recruited because of their past or present use of the NHS	No
• Access to data, organs, or other bodily material of past or present NHS patients	No
• Foetal material and IVF involving NHS patients	No
• The recently dead in NHS premises	No
• Prisoners or others within the criminal justice system recruited for health-related research*	No
• Police, court officials, prisoners, or others within the criminal justice system*	No
• Participants who are unable to provide informed consent due to their incapacity even if the project is not health related	No
2. Is this a research project as opposed to service evaluation or audit?	No
<i>For NHS definitions of research etc. please see the following website</i>	

If you have answered **YES** to questions **1 & 2** then you **MUST** seek the appropriate external approvals from the NHS, Her Majesty's Prison and Probation Service (HMPPS) under their independent Research Governance schemes. Further information is provided below.

<https://www.myresearchproject.org.uk>

NB College Teaching Programme Research Ethics Committees (CTPRECS) provide Independent Scientific Review for NHS or HMPPS research and initial scrutiny for ethics applications as required for university sponsorship of the research. Applicants can use the IRAS proforma and submit this initially to their CTPREC.

1. Checks for Research with Human Participants

Question	Yes/No
1. Will any of the participants be vulnerable? <i>Note: Vulnerable' people include children and young people, people with learning disabilities, people who may be limited by age or sickness, people researched because of a condition they have, etc. See full definition on ethics website</i>	No
2. Are drugs, placebos, or other substances (e.g. food substances, vitamins) to be administered to the study participants or will the study involve invasive, intrusive or potentially harmful procedures of any kind?	No
3. Will tissue samples (including blood) be obtained from participants?	No
4. Is pain or more than mild discomfort likely to result from the study?	No
5. Will the study involve prolonged or repetitive testing?	No
6. Is there any reasonable and foreseeable risk of physical or emotional harm to any of the participants? <i>Note: Harm may be caused by distressing or intrusive interview questions, uncomfortable procedures involving the participant, invasion of privacy, topics relating to highly personal information, topics relating to illegal activity, or topics that are anxiety provoking, etc.</i>	No
7. Will anyone be taking part without giving their informed consent?	No
8. Is it covert research? <i>Note: 'Covert research' refers to research that is conducted without the knowledge of participants.</i>	No
9. Will the research output allow identification of any individual who has not given their express consent to be identified?	No

If you have answered **YES** to any of these questions you are **REQUIRED** to complete and submit a UREC 3 or UREC4). Your supervisor will advise. If you have answered **NO** to all these questions then proceed with this form (UREC 2).

General Details

Name of student	Callum Beckwith
SHU email address	b6023006@my.shu.ac.uk
Course or qualification (student)	Computer Science
Name of supervisor	Michael Marriott

Email address	mm7888@exchange.shu.ac.uk
Title of proposed research	Application to educate those who are unfamiliar with handling sensitive information online
Proposed start date	23 rd October 2020
Proposed end date	15 th April 2021
Background to the study and scientific rationale for undertaking it.	<p>Using money for the exchange of goods and services online is a modern convenience for most. Unfortunately, there is still a large minority of people who lack fundamental computer skills. As a result, online services like e-commerce sites are difficult for these users to understand and operate. This can leave many people feeling socially excluded from the modern world. The goal of this project is to educate those who are unfamiliar or fearful about using online services that require the use of sensitive information.</p> <p>My solution is to produce a secure online application that simulates common procedures a user is expected to go through on sites where sensitive information is required. The application will function with two core users; a teacher and a learner. The final result will allow the learner to visit any trusted e-commerce website and confidently handle private information.</p> <p>Through the help of Barnsley Adult Skills Community Learning I will be able to demonstrate and conclude the usefulness of the deliverable.</p>
Aims & research question(s)	<p>Identify common procedures users will experience when handling their sensitive information online.</p> <p>Identify development frameworks and libraries that will help create a realistic and learner friendly experience.</p> <p>Identify software and methods that ensure all data collected by the solution is relevant and secure.</p> <p>Identify the most appropriate approaches for educating users through online applications.</p> <p>Use an agile development approach by making use of the resources available.</p> <p>Develop a back-end system that supports storing and distributing the application data.</p> <p>Develop a front-end single page application that simulates experiences where the user must deal with sensitive information.</p> <p>Develop a teacher and learner based environment that will allow learners to access the application with minimal computing knowledge.</p> <p>Conclude, when done correctly, if an online educational tool can be utilised effectively to reduce the feeling of social exclusion for users who lack fundamental computer skills.</p>
Methods to be used for: 1.recruitment of participants, 2.data collection, 3. data analysis.	<p>1. Participants will be recruited through Barnsley Adult Skills Community Learning.</p> <p>2. Data collected will occur when a teacher is registered as a member on the site. Learner details will be mostly anonymous except from a nickname and a learner code. Results of learner tests will also be</p>

	<p>stored in the system.</p> <p>3. Data analysed will be used on previously stored learner task results which will help evaluate their performance and abilities.</p>
Outline the nature of the data held, details of anonymisation, storage and disposal procedures as required.	<p>One primary part of the data held will be learner results. This will consist of time taken to complete a task and what items in a task they complete. A smaller percentage of the data will be for users who fall under the category of a teacher. These users will require an account which will expect storage of their email address, full name, and a chosen password. Passwords will be secured using a hashing algorithm.</p> <p>Data will be stored on a relational database.</p> <p>At the end of the report the data will no longer be necessary and will be disposed of.</p>

3. Research in Organisations


Question	Yes/No
1. Will the research involve working with/within an organisation (e.g. school, business, charity, museum, government department, international agency, etc.)?	Yes
2. If you answered YES to question 1, do you have granted access to conduct the research? <i>If YES, students please show evidence to your supervisor. PI should retain safely.</i>	Yes
3. If you answered NO to question 2, is it because: A. you have not yet asked B. you have asked and not yet received an answer C. you have asked and been refused access. <i>Note: You will only be able to start the research when you have been granted access.</i>	


4. Research with Products and Artefacts

Question	Yes/No
1. Will the research involve working with copyrighted documents, films, broadcasts, photographs, artworks, designs, products, programmes, databases, networks, processes, existing datasets, or secure data?	Yes

<p>2. If you answered YES to question 1, are the materials you intend to use in the public domain?</p> <p><i>Notes: 'In the public domain' does not mean the same thing as 'publicly accessible'.</i></p> <ul style="list-style-type: none"> Information which is 'in the public domain' is no longer protected by copyright (i.e. copyright has either expired or been waived) and can be used without permission. Information which is 'publicly accessible' (e.g. TV broadcasts, websites, artworks, newspapers) is available for anyone to consult/view. It is still protected by copyright even if there is no copyright notice. In UK law, copyright protection is automatic and does not require a copyright statement, although it is always good practice to provide one. It is necessary to check the terms and conditions of use to find out exactly how the material may be reused etc. <p><i>If you answered YES to question 1, be aware that you may need to consider other ethics codes. For example, when conducting Internet research, consult the code of the Association of Internet Researchers; for educational research, consult the Code of Ethics of the British Educational Research Association.</i></p>	Yes
<p>3. If you answered NO to question 2, do you have explicit permission to use these materials as data?</p> <p><i>If YES, please show evidence to your supervisor.</i></p>	
<p>4. If you answered NO to question 3, is it because:</p> <p>A. you have not yet asked permission</p> <p>B. you have asked and not yet received an answer</p> <p>C. you have asked and been refused access.</p> <p><i>Note You will only be able to start the research when you have been granted permission to use the specified material.</i></p>	A/B/C

Adherence to SHU policy and procedures

Personal statement	
<p>I can confirm that:</p> <ul style="list-style-type: none"> I have read the Sheffield Hallam University Research Ethics Policy and Procedures I agree to abide by its principles. 	
Student	
Name: Callum Beckwith	Date: 14/10/2020
Signature: 	
Supervisor or other person giving ethical sign-off	
<p>I can confirm that completion of this form has not identified the need for ethical approval by the FREC or an NHS, Social Care or other external REC. The research will not commence until any approvals required under Sections 3 & 4 have been received and any necessary health and safety measures are in place.</p>	
Name: Mick Marriott	Date: 22/10/2020

Signature: 	
Additional Signature if required by course:	
Name:	Date:
Signature:	

Please ensure the following are included with this form if applicable, tick box to indicate:

	Yes	No	N/A
Research proposal if prepared previously	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Any recruitment materials (e.g. posters, letters, etc.)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Participant information sheet	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Participant consent form	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Details of measures to be used (e.g. questionnaires, etc.)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Outline interview schedule / focus group schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Debriefing materials	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Health and Safety Project Safety Plan for Procedures	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Appendix B

Learner Participation Sheet

Application to educate those who are unfamiliar with handling online services. Learning the internet

You have been selected to take part in testing and evaluating the educational website “Learning the Internet”. Learning the internet is a tool for users who have a minimal knowledge about online services. The web application intends to educate these users by walking them through a simulated online service. You are being asked to participate as a user that will interact with a tutorial and an examination course.

You have been selected to take part in this research as you are currently working with Barnsley Adult Skills and Community Learning. The research project is heavily focused on teaching and improving users’ Essential Digital Skills. This is an important skill that Barnsley Adult Skills Community Learning integrate within their computer courses meaning you are part of a relevant demographic for this research project. You do not have to take part if you do not want to. You can withdraw at any time without giving a reason, or even decide not to answer a particular question.

For interacting with the online application, you will be expected to have an internet connection with an internet capable laptop, desktop, or tablet. Preferably using the “Google Chrome” internet browser for accessing the online application. You will be given a learning code from your teacher as well as a link. You will use this link to access the online application. There, you will enter the code to access the tutorial and examination. Once you have completed the tutorial and examination you will be asked to complete two surveys. The first survey will ask you about your experience and will ask for some general feedback. The second survey will be a SUS survey. Your surveys will be recorded and used for analytical and evaluation purposes within the research project. The process will take around 10 to 30 minutes and will take place online.

There are no possible risks involved with taking part. Survey results will be stored on Google’s secure servers and application data will be stored on a secure server hosted by Digital Ocean. All survey results will be anonymous and there will be no way of tracing them back to you. All information collected by the online application will be cleared once the research project is over. All application and survey data during the time of the project will only be accessible by the research author (Callum Beckwith).

The research project will last until 19th April 2021. After that time, if you have any interest in the results you can get in touch with the given contact information in this document.

The University undertakes research as part of its function for the community under its legal status. Data protection allows us to use personal data for research with appropriate safeguards in place under the legal basis of public tasks that are in the public interest. A full statement of your rights can be found at <https://www.shu.ac.uk/about-this-website/privacy-policy/privacynotices/privacy-noticefor-research>.

However, all University research is reviewed to ensure that participants are treated appropriately, and their rights respected. Further information at <https://www.shu.ac.uk/research/ethics-integrityand-practice>.

If there are any further questions regarding the participation or the research project itself, please use the following contact details:

b6023006@my.shu.ac.uk

Details of who to contact if you have any concerns or if adverse effects occur after the study are given below.

You should contact the Data Protection Officer if:

- you have a query about how your data is used by the University • you would like to report a data security breach (e.g. if you think your personal data has been lost or disclosed inappropriately)
- you would like to complain about how the University has used your personal data

DPO@shu.ac.uk

You should contact the Head of Research Ethics (Professor Ann Macaskill) if:

- you have concerns with how the research was undertaken or how you were treated

a.macaskill@shu.ac.uk

Appendix C

Teacher Participation Sheet

Application to educate those who are unfamiliar with handling online services. Learning the internet

You have been selected to take part in testing and evaluating the educational website "Learning the Internet". Learning the internet is a tool for users who have a minimal knowledge about online services. The web application intends to educate these users by walking them through a simulated online service. You are being asked to participate as a teacher that will manage a classroom and provide learners with necessary information.

You have been selected to take part in this research as you are currently working at Barnsley Adult Skills and Community Learning. The research project is heavily focused on teaching and improving users' Essential Digital Skills. This is an important skill that Barnsley Adult Skills and Community Learning integrate within their computer courses meaning you are part of a relevant demographic for this research project. You do not have to take part if you do not want to. You can withdraw at any time without giving a reason, or even decide not to answer a particular question.

For interacting with the online application, you will be expected to have an internet connection with an internet capable laptop, desktop, or tablet. Preferably using the "Google Chrome" internet browser for accessing the online application. You will be asked to follow an instruction sheet which will guide you on how to use the application as a teacher. After your learners have completed their tutorials and examinations you will be asked to complete two surveys. The first survey will ask you about your experience and will ask for some general feedback. The second survey will be a SUS survey. Your surveys will be recorded and used for analytical and evaluation purposes within the research project. The time taken for this process is dependent on the time taken by the learners you have chosen to participate in the project.

There are no possible risks involved with taking part. Survey results will be stored on Google's secure servers and application data will be stored on a secure server hosted by Digital Ocean. All survey results will be anonymous and there will be no way of tracing them back to you. All information collected by the online application will be cleared once the research project is over. All application and survey data during the time of the project will only be accessible by the research author (Callum Beckwith).

The research project will last until 19th April 2021. After that time, if you have any interest in the results you can get in touch with the given contact information in this document.

The University undertakes research as part of its function for the community under its legal status. Data protection allows us to use personal data for research with appropriate safeguards in place under the legal basis of public tasks that are in the public interest. A full statement of your rights can be found at <https://www.shu.ac.uk/about-this-website/privacy-policy/privacynotices/privacy-noticefor-research>.

However, all University research is reviewed to ensure that participants are treated appropriately, and their rights respected. Further information at <https://www.shu.ac.uk/research/ethics-integrityand-practice>.

If there are any further questions regarding the participation or the research project itself, please use the following contact details:

b6023006@my.shu.ac.uk

Details of who to contact if you have any concerns or if adverse effects occur after the study are given below.

You should contact the Data Protection Officer if:

- you have a query about how your data is used by the University • you would like to report a data security breach (e.g. if you think your personal data has been lost or disclosed inappropriately)
- you would like to complain about how the University has used your personal data

DPO@shu.ac.uk

You should contact the Head of Research Ethics (Professor Ann Macaskill) if:

- you have concerns with how the research was undertaken or how you were treated

a.macaskill@shu.ac.uk

Appendix D

Teacher Instruction Sheet

Learning the internet

Teacher Participation Instruction Sheet

Thank you for being a participant in this research project. The following instructions are to help you set up a teaching account with the online application “learning the internet”.

Please ensure that before you begin the instructions you have read and signed the consent form.

Instructions

- 1) Signing up to the application.
 - a) Navigate to the following url: <https://www.learning-the-internet.co.uk>
 - b) In the top right corner, there is a “Teacher Login” button. Click it.
 - c) Click the sign-up tab on the login box.
 - d) Register your details with the application.
 - e) Make sure you remember your Email address and Password as you will be required to enter them at the login screen if you visit the application later.
 - f) Once you have clicked “Sign Up” you will be redirected to the teaching home screen
- 2) Creating a classroom
 - a) Classrooms help you organise your learners. To Create a new one, click “Create Classroom” button in the centre of the screen.
 - b) Give your classroom a name.
 - c) At this stage you are also able to add some learners to the class with the box below. Type in their name and click “Add”. You are also able to add learners to the class later so don’t worry if you forget one.
- 3) Teaching Dashboard
 - a) You can now see all your learners. You are also able to see how many tutorials and exams they have completed. Bear in mind that learners who may have completed a tutorial and restarted it will not show as having completed the tutorial if it is still in progress.
 - b) You must give the learners their dedicated learner code. You can do this by clicking the button that says, “Click to Copy” and the send the contents of your clipboard to the learner.
 - c) The learner should be able to enter their code at either of the following links:
 - i) <https://www.learning-the-internet.co.uk>
 - ii) <https://www.learning-the-internet.co.uk/Learn-Login>
- 4) Surveys
 - a) You and your learners can then fill in the following surveys to help the evaluation of the research project.
 - i) General Feedback <https://forms.gle/6JnWMoKqLqiMbjkDA>
 - ii) SUS Feedback <https://forms.gle/6Sf23mtSYd7ddUPX6>

Appendix E

User Consent Form

PARTICIPANT CONSENT FORM

TITLE OF RESEARCH STUDY: Application to educate those who are unfamiliar with handling online services.

Please answer the following questions by ticking the response that applies

- | | YES | NO |
|--|--------------------------|--------------------------|
| 1. I have read the Information Sheet for this study and have had details of the study explained to me. | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any point. | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. I understand that I am free to withdraw from the study within the time limits outlined in the Information Sheet, without giving a reason for my withdrawal or to decline to answer any particular questions in the study without any consequences to my future treatment by the researcher. | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. I agree to provide information to the researchers under the conditions of confidentiality set out in the Information Sheet. | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. I wish to participate in the study under the conditions set out in the Information Sheet. | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. I consent to the information collected for the purposes of this research study, once anonymised (so that I cannot be identified), to be used for any other research purposes. | <input type="checkbox"/> | <input type="checkbox"/> |

Participant's Signature: _____ **Date:** _____

Participant's Name (Printed): _____

Contact details:

Researcher's Name (Printed): Callum Beckwith

Researcher's Signature:



Researcher's contact details:

Address: 15 Queens View, 88 Park Grange Road, Sheffield S2 3RY

Email Address: b6023006@my.shu.ac.uk

Please keep your copy of the consent form and the information sheet together.

Appendix F

User General Feedback Questions

Learning the internet Feedback Survey

First of all, I'd like to thank you for taking the time to take part in testing learning-the-internet.co.uk. I appreciate that you have taken time out of your day to help with my research project! Again, thank you!

***Required**

1. What device type of device did you access the application on?

Mark only one oval.

- ☐ Laptop
- ☐ Desktop
- ☐ Small tablet or Ipad
- ☐ Regular sized tablet or iPad
- ☐ Mobile phone

2. Do you think the application provides a suitable way to learn for people who are new to the internet?

3. Do you think the look and feel of the application are appropriate for its purpose?

4. What suggestions would you make to improve the experience you have just had?

5. Did you encounter any issues or bugs within the application?

6. Would you recommend this application to users who are just starting to learn about the internet?

Mark only one oval.

☐ yes

☐ no

☐ Other: _____

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Google Forms

Appendix G

User SUS Feedback Questions

Learning the internet SUS Feedback

First of all, I'd like to thank you for taking the time to take part in testing learning-the-internet.co.uk. I appreciate that you have taken time out of your day to help with my research project! Again, thank you!

1. I think that I would like to use this system frequently

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

2. I found the system unnecessarily complex

Mark only one oval.

	1	2	3	4	5	
Strongly Agree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Disagree

3. I thought the system was easy to use

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

4. I think that I would need the support of a technical person to be able to use this system

Mark only one oval.

	1	2	3	4	5	
Strongly Agree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Disagree

5. I found the various functions in this system were well integrated.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

6. I thought there was too much inconsistency in this system

Mark only one oval.

	1	2	3	4	5	
Strongly Agree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Disagree

7. I would imagine that most people would learn to use this system very quickly

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

8. I found the system very cumbersome to use

Mark only one oval.

	1	2	3	4	5	
Strongly Agree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Disagree

9. I felt very confident using the system

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

10. I needed to learn a lot of things before I could get going with this system

Mark only one oval.

	1	2	3	4	5	
Strongly Agree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Disagree

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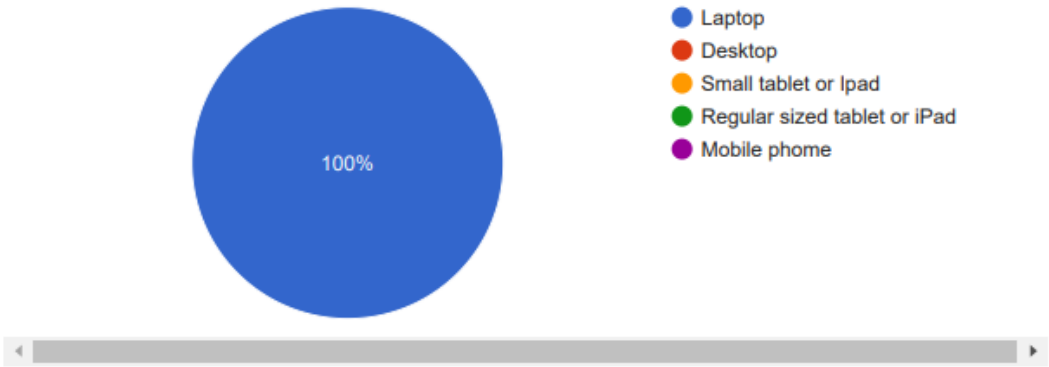
Google Forms

Appendix H

User General Feedback Results

What device type of device did you access the application on?

5 responses



Do you think the application provides a suitable way to learn for people who are new to the internet?

5 responses

I think it was easy to follow

YES

Yes, but I would have liked the option of a sound tutorial. Thinking of people that aren't already using the internet, there might be some literacy issues that would prevent them from using this application.

I do yes

It gives a very good insight into how a shopping site works on the internet

Do you think the look and feel of the application are appropriate for its purpose?

5 responses

Yes it wasn't complicated

YES

I do generally, but thought the text came up a little too quickly and this might be off putting and seem more advanced/complicated than it is. I think a 'back' button to recap on the previous page would help a beginner as well, as when you are first learning something there is a lot to take in and you can forget what is on the previous page/s

Yes

Yes because it isn't inundated with adverts that sometimes cause confusion ie not knowing whether they are part of the actual shop or not. The site is easy to see and the instructions are clear. I now have a better understanding of what filters and tags do too.

What suggestions would you make to improve the experience you have just had?

5 responses

I don't have one. It worked good

NONE, THE WEBSITE WAS VERY EASY TO FOLLOW

Be more specific about what a 'navigation bar' is. People who haven't used the internet before may literally be looking for a bar with navigation written in it. Maybe show a picture with a ring around it and an arrow pointing to it after mentioning it.

Also rather than say click 'checkout', the button actually says 'go to checkout', so I think to avoid confusion with new learners, be very accurate and specific.

If you click on something in error the screen does not do anything. A little pop up/prompt would be useful to acknowledge the user where they have gone wrong and direct them to answer correctly.

As I said above, I think that a sound tutorial would be beneficial to some users and the text displaying a little slower would make it seem less advanced/complicated.

Know whats going on at the course page

Have even more items in the shop so that it isn't as easy to scroll through them and you have to use the filters to find specific items.

Did you encounter any issues or bugs within the application?

5 responses

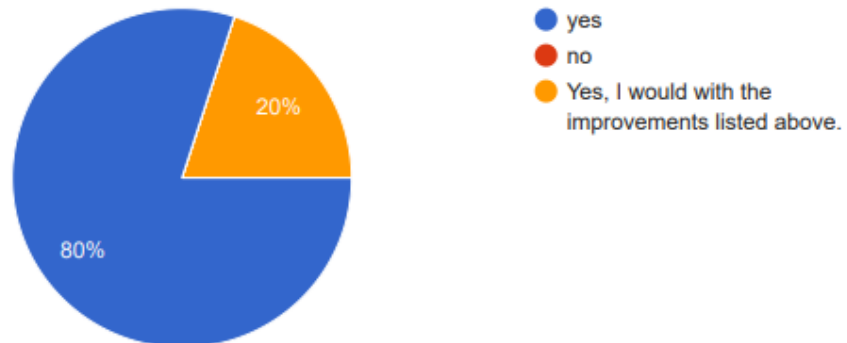
No

NO

nope

Would you recommend this application to users who are just starting to learn about the internet?

5 responses

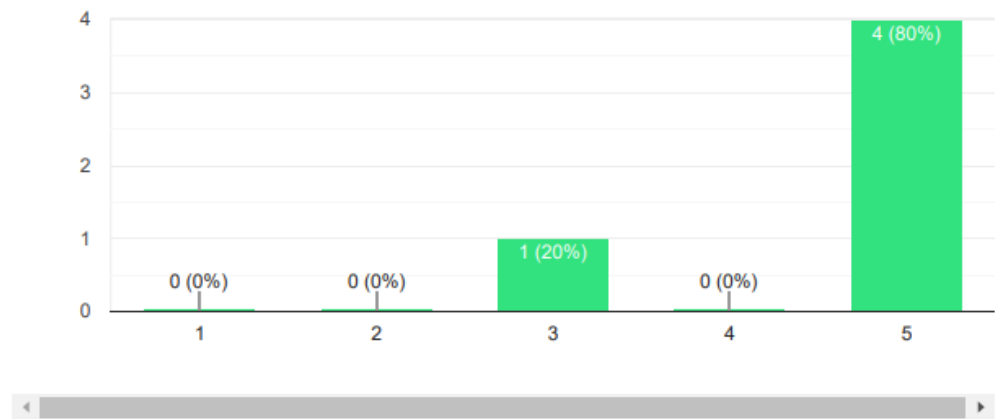


Appendix I

User SUS Feedback Results

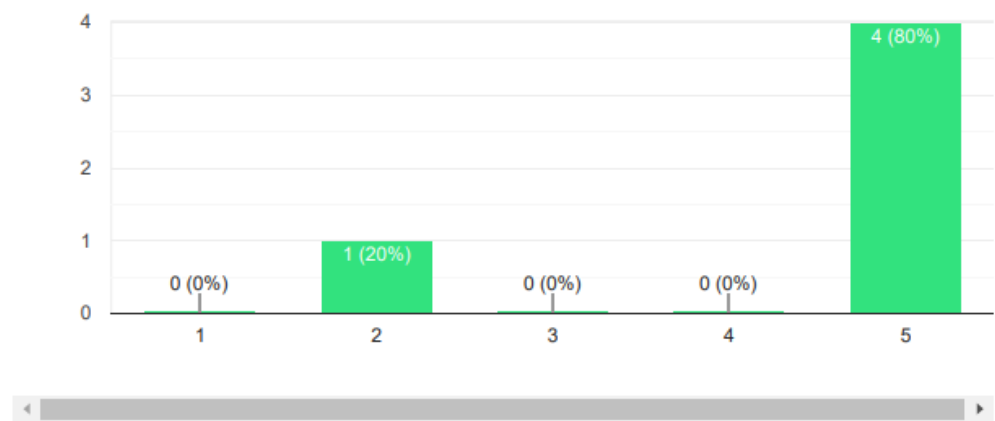
I think that I would like to use this system frequently

5 responses



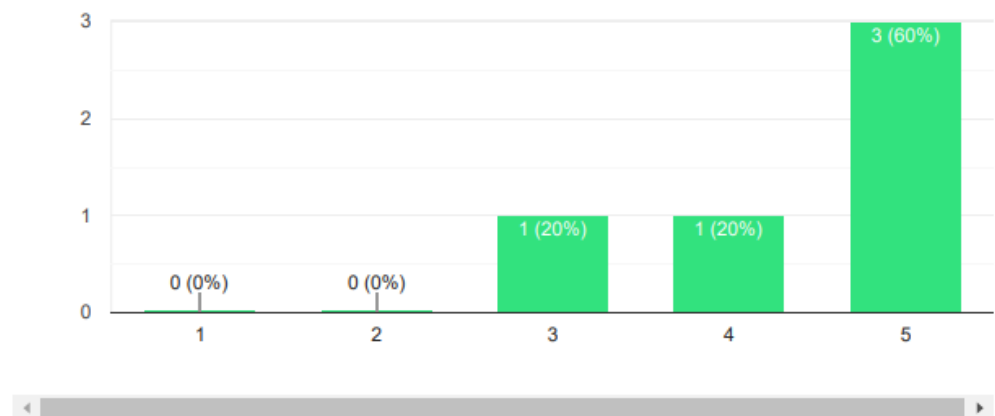
I found the system unnecessarily complex

5 responses



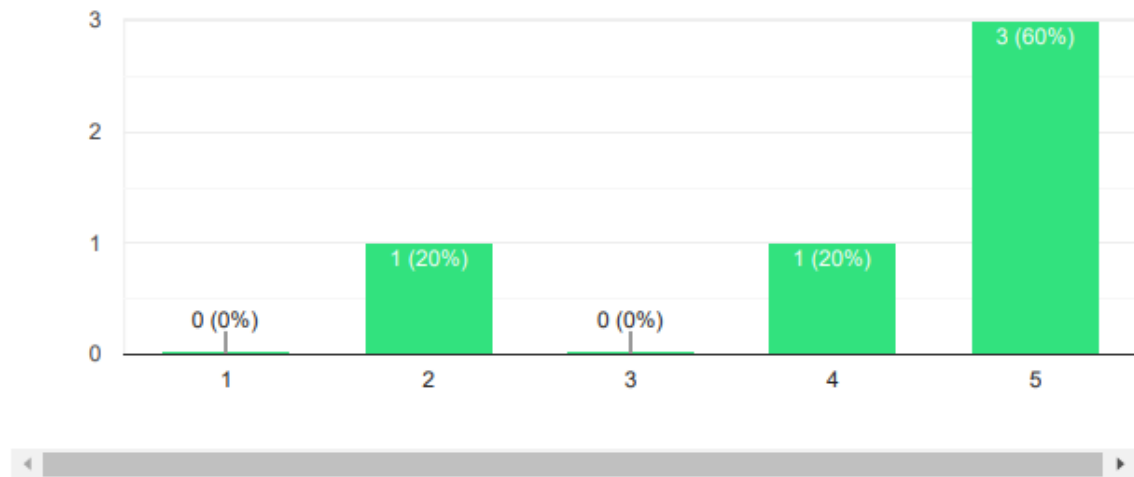
I thought the system was easy to use

5 responses



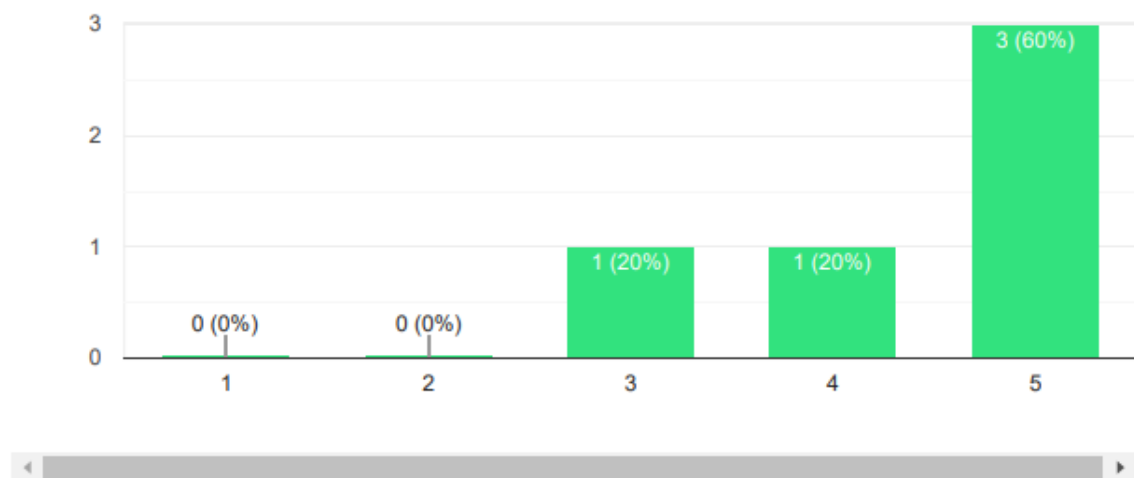
I think that I would need the support of a technical person to be able to use this system

5 responses



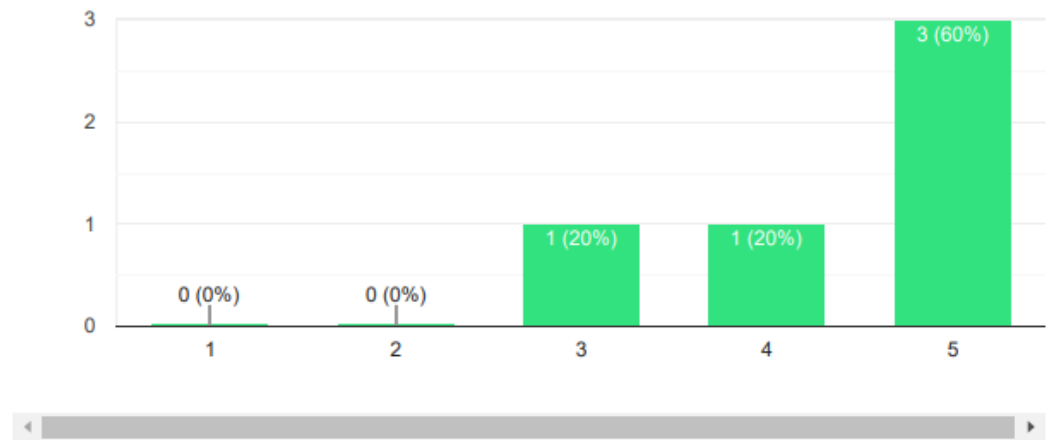
I found the various functions in this system were well integrated.

5 responses



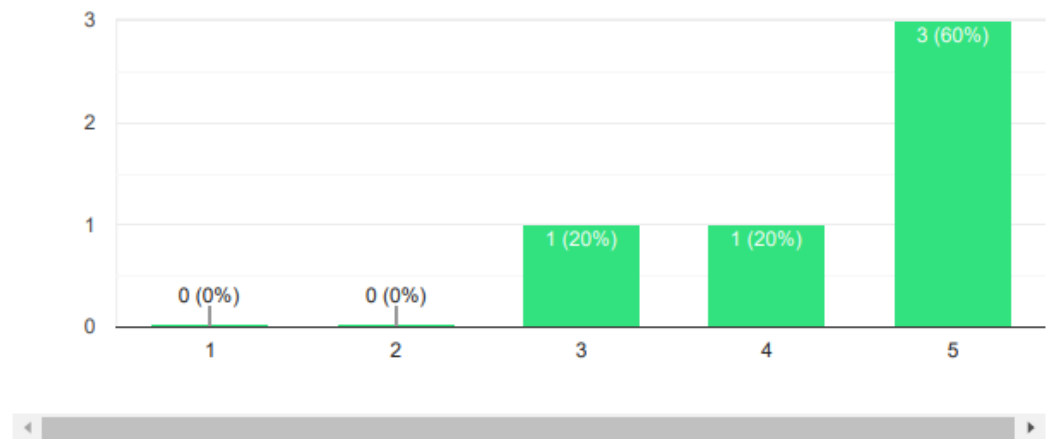
I thought there was too much inconsistency in this system

5 responses



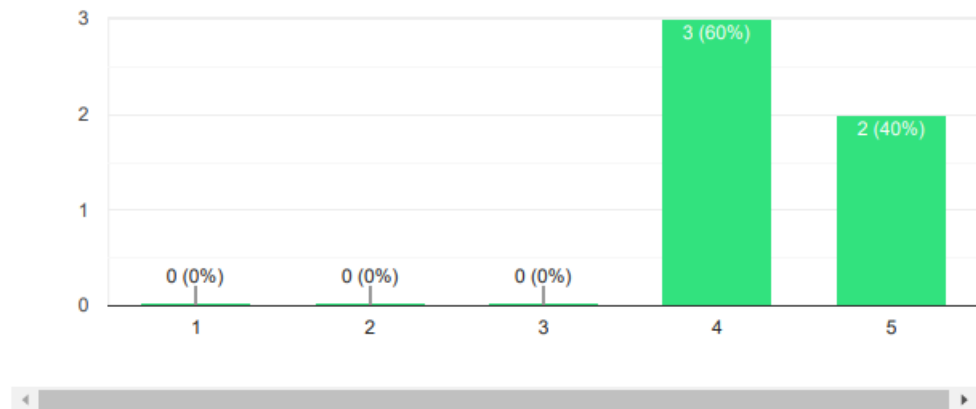
I would imagine that most people would learn to use this system very quickly

5 responses



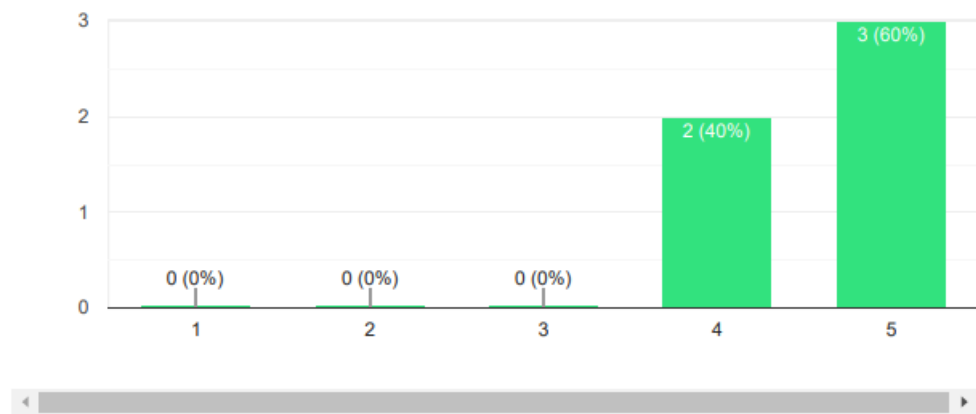
I found the system very cumbersome to use

5 responses



I felt very confident using the system

5 responses



I needed to learn a lot of things before I could get going with this system

5 responses

