

Interactive Learning Website

Nabil Ghayyda

H00300894

MEng Software Engineering Year 4

Deliverable 2: Final Year Dissertation

Supervisor:

Lilia Georgieva

Second Reader:

Hend El Mohandes

# Declaration

I, Nabil Ghayyda confirm the work submitted for this dissertation is all my own work and is conveyed using my own words. Any work used from other authors in any shape or form (e.g., equations, tables, ideas, texts…) are always fully and properly acknowledged. A reference list is included.

Signed: Nabil Ghayyda

Date: 30th October 2021

# Abstract

Interactive online learning entails going beyond the passive one-way nodes of reading, listening, and watching static content. It includes pulling out the exact content you want and manipulating it rather than just waiting for information and digesting it. It has been widely demonstrated in the current literature that the use of interactive learning materials in Education has the potential to enhance user engagement and active learning. The term ‘gamification’ is generally used to denote the application of game mechanisms in non-gaming environments with the aim of enhancing the processes enacted and the experience of those involved. In August 2010 Devhub announced an increase in the number of users who completed their online tasks from 10% to 80% after adding gamification elements. Social websites like Facebook, Twitter and Linkedin now have implemented game elements into their sign-up & account processes as a result of DevHub's success.

The purpose of this dissertation project is the implementation and evaluation of RPL, a gamified interactive learning website that enables users to undertake interactive gamified courses regarding the raspberry pi. The system aims to achieve a fulfilling course experience through the implementation of its interactive and gamified features. Additionally it aims to achieve increased engagement and retention through the use of gamification by implementing gamified mechanics, these include; unlockable achievements, gaining experience, levelling up and a progression system. There was then an evaluation of the completed system, that measured how well RPL performed by its given task. The evaluation took the form of a user study that was conducted using students from Heriot-Watt University. The subjective user experience was measured using a questionnaire.

# Acknowledgements

I would like to thank Professor Lilia Georgieva for proposing this topic and her guidance throughout the entire process of this project.

Additionally I’d like to thank the second reader Hend El Mohandes.

Table of Contents

[Declaration 2](#_Toc88431250)

[Abstract 3](#_Toc88431251)

[Acknowledgements 4](#_Toc88431252)

[1. Introduction 7](#_Toc88431253)

[1.1. Aims 7](#_Toc88431254)

[1.2. Objectives 8](#_Toc88431255)

[1.3. Outline 9](#_Toc88431256)

[2. Literature Review 10](#_Toc88431257)

[2.1. Raspberry Pi 10](#_Toc88431258)

[2.1.1. What is a Raspberry Pi? 10](#_Toc88431259)

[2.1.2. Raspbian OS 10](#_Toc88431260)

[2.1.3. Python Programming on Raspberry Pi 11](#_Toc88431261)

[2.1.4 Interactive Learning for Raspberry Pi’s 11](#_Toc88431262)

[2.1. Duolingo 12](#_Toc88431263)

[2.1.1. UI/UX – Duolingo 13](#_Toc88431264)

[2.1.2. Security features – Duolingo 16](#_Toc88431265)

[2.1.2. Gamification and Engagement – Duolingo 16](#_Toc88431266)

[2.1.2. Technology – Duolingo 17](#_Toc88431267)

[2.3. Interactive Online Learning 17](#_Toc88431268)

[2.3.1. Effectiveness of Interactive Online Learning 17](#_Toc88431269)

[2.4. Gamification of Interactive Online Learning 19](#_Toc88431270)

[2.4.1. Gamification Promotes User Engagement 20](#_Toc88431271)

[2.5. React.js & Angular.js on Interactive Websites 21](#_Toc88431272)

[2.5.1 React.js 21](#_Toc88431273)

[2.5.2 Angular.js 22](#_Toc88431274)

[2.6. Login and Security Features 23](#_Toc88431275)

[3. Requirements Analysis 24](#_Toc88431276)

[3.1 Stakeholder Analysis 24](#_Toc88431277)

[3.2 Approach 24](#_Toc88431278)

[3.3. Functional Requirements 26](#_Toc88431279)

[3.4. Non-Functional Requirements 29](#_Toc88431280)

[4. Evaluation Analysis 30](#_Toc88431281)

[5. Project Management 31](#_Toc88431282)

[5.1. Project Schedule – Initial Gantt Chart 31](#_Toc88431283)

[5.2. Risk Analysis 32](#_Toc88431284)

[5.3. Professional, Legal, Ethical and Social Issues 34](#_Toc88431285)

[5.3.1 Ethical Issues 34](#_Toc88431286)

[5.3.2 Legal Issues 34](#_Toc88431287)

[6. References 35](#_Toc88431288)

[7. Appendices 38](#_Toc88431289)

[Appendix A – Consent Form 38](#_Toc88431290)

# 1. Introduction

This chapter will discuss the motivations behind creating RPL as well as outline the aims and objectives for this project. It will also contain an overview of the sections covered in this report, as well as a brief summary of the information included in each section.

## 1.1. Aims

This project aims to:

* To implement and evaluate a gamified interactive website, RPL, that should be able to effectively teach users the basics regarding raspberry pi’s such as setting up a raspberry pi and using a raspberry pi for the first time. It should allow the user to answer interactive questions, this includes selecting an answer or inputting an answer. It should be able to display a users level and progression through each course. It should be able to allow users to unlock achievements as they progress through a course and gain experience as they answer questions.
* To compare engagement and retention levels of the implemented gamified interactive website to a version of the website that has it’s gamified features removed.

## 1.2. Objectives

These are the objectives that need to be met in order to achieve these aims:

* Research into Raspberry Pi’s to identify the content to be taught in the online course and review the relevant literature on interactive online learning.
* Identify the gamification features to include in the interactive website that would allow for a more engaging online learning experience for the user. The features are identified by reviewing existing online interactive learning platforms with gamified features.
* Review relevant literature regarding the features that were identified, such as case studies that backup the usefulness of these features – showing they are effective to learning or allow for additional user engagement.
* Research into frameworks and libraries that may help the developmental process and decide which ones to use, the ones I will review are react.js and angular.js.
* Build a list of prioritised requirements from the research conducted on the features to include in the website.
* Develop the new interactive website:
  + Implement a login system
  + Implement a Raspberry Pi “curriculum”
  + Add interactive elements to the online learning website
  + Add gamified features, exp and rewards for completion of chapters of the curriculum
  + Have progression of the “course” visible to the user
* Evaluate the final system based on more user feedback and discuss future improvements

## 1.3. Outline

The report will be structured into 7 separate sections, this is a brief analysis of each section and what they contain:

1. Introduction: The introduction introduces the project and the concepts related to it. Additionally, it lists the aims and objectives in a clear, precise manner.
2. Literature Review: This section discusses the background literature related to this project and reviews similar existing applications,
3. Requirements Analysis: This section discusses the stakeholders of the project and the approach of this project. Additionally, it discusses the functional and non-functional requirements of the system.
4. Evaluation Strategy: This section discusses briefly the details of the evaluation to be conducted and the analysis.
5. Project Management: This section discusses the project plan in the form of a gantt chart outlining the entire plan of the project for the year. Also, it discusses the risks associated with the project and steps to mitigate them. Lastly, it discusses the potential professional, legal, ethical and social issues pertaining to the project.
6. References: Contains a bibliography of all the references used within the project.
7. Appendix: Contains a list of material related to the project, e.g. consent form.

# 2. Literature Review

## 2.1. Raspberry Pi

This section will review user guides regarding Raspberry Pi’s in order to extract the relevant material needed for the course content. The three courses are ‘Introduction to Raspberry Pi’, ‘Raspbian OS’ and ‘Python Projects on the Raspberry Pi’. There is a lot of documented material regarding Raspberry Pi’s, there are multiple user guides that have been cited by hundreds of individuals. Some of these user guides include, (Upton & Halfacree, 2014) – Raspberry Pi User Guide, (Richardson & Wallace, 2014) – Getting started with Raspberry Pi and (Upton & Halfacree, 2012) – Meet the Raspberry Pi. This section is important as the information here will be part of the main curriculum within the gamified interactive online learning system.

### 2.1.1. Introduction to Raspberry Pi

As stated by Upton & Halfacree, (2014) Raspberry Pi user guide; “The Flexibility of the Raspberry Pi makes it a good choice as a low-power, general-purpose desktop computer.” You can perform all tasks on a Raspberry Pi as you’d expect on a standard computer. It allows for users of all ages to explore computing and various other things such as learn how to program in python.

The initial step in getting started with the Raspberry Pi Is setting it up. The paper by Richardson & Wallace (2014) has an in-depth guide on how to set up a Raspberry Pi under the chapter conveniently named “Getting Up and Running”. This chapter covers all the essentials such as a general tour of the different Raspberry Pi boards, the peripherals you will need, the case, choosing the distribution suitable for what the user needs, flashing the SD Card… etc

The content of the course will take inspiration from this particular paper and will be the material covered within the first course ‘Introduction to the Raspberry Pi’.

### 2.1.2. Raspbian OS

Raspbian OS (Harrington, 2015) is an operating system designed for the Raspberry Pi hardware, it is completely free and based on Debian which is a linux operating system. The official Raspbian website2 provides a lot of information regarding the OS. Raspbian comes with over 35,000 packages bundled for simple installation onto your Raspberry Pi.

The first build of Raspbian built and optimised for the Raspberry Pi was completed in 2012, but since then it has been in constant development to actively improve the stability and performance of all the packages bundled with the operating system.

There are various texts regarding Raspbian to teach readers of varying abilities how to use Raspbian effectively. One is Learrning Raspbian – (Harrington, 2015), the purpose of this as stated from the text: “This book is written for beginners who wish to learn how to make the most out of their Raspberry Pi”. The most important takeaway from this text is that it will teach users how to customise their desktop environment to suit their requirements and taste and how to install and manage the software packages on the users Raspberry Pi. These are both essential regarding the learning process of the Raspberry Pi.

### 2.1.3. Python Programming on Raspberry Pi

There are many uses for the Raspberry Pi such as controlling a robot with one, building a webserver on one, learning how to code on one, etc… The use that will be explored within the interactive website is learning how to program in python on the Raspberry Pi. Python is a general-purpose programming language used in a variety of ways. As stated on the official Python website; “Python’s simple, easy to learn syntax emphasises readability and therefore reduces the cost of programming maintenance”. This implies that python is a beginner friendly programming language, allowing users of all backgrounds to pickup and learn python. Some relevant texts for specifically learning Python on a Raspberry Pi exist, such as Learn Raspberry Pi Programming with Python –

(Donat & Krause, 2014) this text guides you through different python programming projects that the user can do on their Raspberry Pi, such as a web spider, weather station and much more.

### 2.1.4 Interactive Learning for Raspberry Pi’s

The official website for Raspberry Pi’soffers lots of great interactive material for the Raspberry Pi, but this mostly comes in the form of projects and programming aspect of the Raspberry Pi. Setting up your Raspberry Pi and other general material is taught to the readers in a monotonous textual manner. This is the case for a lot of the websites that showcase any material regarding the Raspberry Pi. One interactive website showcases an interactive Raspberry Pi Pinout, this Pinout is an interactive reference towards the GPIO Pins found on the Raspberry Pi, it’s also a guide for the Pi’s interfaces. The interactive Pinout can be seen below.

Diagram

Description automatically generated

*figure 1.1 – gPio Pinout, sourced from Pinout.xyz*

## 2.1. Duolingo

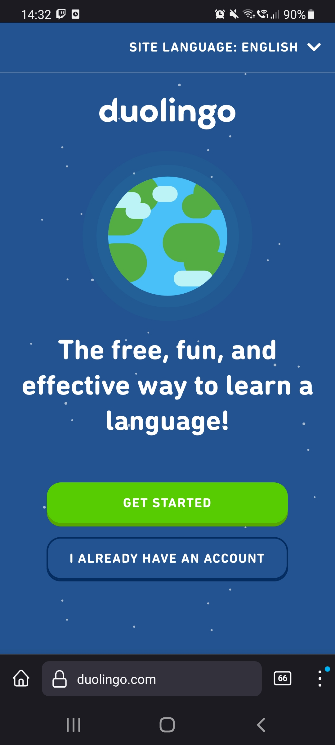
Throughout this section of the project there will be a discussion and review Duolingo, an interactive website with gamified elements. This is done to gain a better idea of what makes this site popular by reviewing Duolingo’s features in order to gain inspiration for features to implement for the gamified interactive system to be developed.

Duolingo to date is the most popular language learning app, as of May 2020 it had over 500 million users of the app worldwide. The app is designed to feel like a game to make education fun, it is also proven that it’s gamification elements are effective in learning.

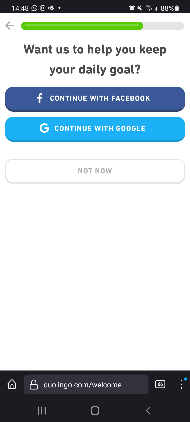
### 2.1.1. UI/UX – Duolingo

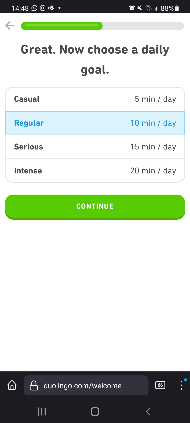
The initial screen disguises the app as an enjoyable video game, featuring a blue background in a cartoonish kind of style with it’s starry night sky background. (McGowan, 2021) (Panchaud, 2021)

Upon first opening the duolingo, it states: “The free, fun, and effective way to learn a language!”, This statement clearly represents what the app is all about to the user. It summarises to the user that the app is free and that it works well for it’s intended purpose. Additionally a Call-To-Action (CTA) is clearly displayed on the page making it easy for the user to move forward. As seen in figure 1.2.



*figure 1.2 - initial duolingo screen, sourced from the official duolingo website*

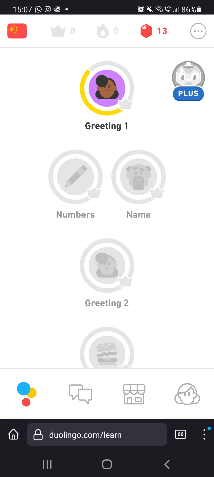
Clicking “Get Started”, it was expected that there would be a screen to prompt the user to create an account. Instead, it displays a list of languages intending for the user to choose which language right away. Visually the screen is quite pleasing displaying the list of languages with the respective flag from which the language originates from. This is a desirable feature of Duolingo, allowing the user to get started on lessons straight away delaying the sign up process that can a lot of the time deter the user from using the app. This ties in with Jared Spools famous 300 million dollar button article where allowing users to checkout without the need to login or create an account significantly increased the number of customers purchasing from there website.



*figure 1.3 - Daily goals Duolingo, figure 1.4 - Duolingo notifications,*

*sourced from the official duolingo website sourced from the official duolingo website*

After a short survey you are asked to complete from Duolingo, you are prompted to select your daily goal regarding how long you plan to use the website for everyday learning, as seen in figure 1.3. What comes next is quite an intuitive feature from Duolingo asking if you would like to be reminded of your daily goal, you have two options allowing you to link either your Facebook or google account., as seen in figure 1.4. It is assumed you receive a notification if you decide to link Duolingo to either application. Additionally, you can decide not to receive any notifications. Studies have been done on notifications and how they help users engage with the specified app on a regular basis. They found push notifications with messages for the user do increase user engagement. (Pham et al, 2016)

 *figure 1.5 - Duolingo course screen, sourced from the official duolingo website*

Next Duolingo prompts the user with a few questions regarding their current ability with the language, after that is done with the user is promptly thrown into their first lesson. It is seen that the course screens are all very appealing, nicely designed and it’s structured to be very simple to use. As seen in figure 1.5.

 *figure 1.5 - Duolingo lesson screen, sourced from the official duolingo website*

The use of radio buttons during the lesson are very usable and appropriate, as seen in figure 1.5. The majority of users use the Duolingo app – these buttons allow for easy and quick entry on touch screen.

In general Duolingo follows quite a light UI pattern with the use of pastels, thin lines, soft edges… The use of reds, greens and blue as primary colours in Duolingo have different purposes. Blue is used for actionable UI i.e. pressing the blue speaker button during a lesson to hear the pronunciation of the word or sentence being said. Reds are primarily used to get the users attention regarding something, or displays an error if the user got a question wrong, etc. Greens are used mainly for the positive features such as congratulating the user for successfully getting a question correctly. Studies have been done on the use of colours and how they impact appeal and a users cognitive processes. It was found that the colours used were a key factor in determining how users interact with the website. (Bonnaderl et al, 2011)

### 2.1.2. Security features – Duolingo

During the sign up process for Duolingo, only a minimal amount of personal information about the user is required age and email are the only requirements. Name being optional. The reason why age is required is to due to the fact one of the features of Duolingo, the discussion board, is only available to users aged 13 or older.

Duolingo has the features of being able to follow users. To allow for further security for it’s members it additionally has the feature to be able to block members.

### 2.1.2. Gamification and Engagement – Duolingo

The gamification element of Duolingo is what separates it from other language learning apps. It is what defines Duolingo. It’s role as a reinforcement mechanism to learn the language allows it to further enhance the engagement of the users of Duolingo.

One of the gamification elements of Duolingo is how the curriculum is structured into bite-sized chapters that can be completed in a matter of minutes. Additionally completing these particulars chapters allow the user to eventually unlock the ability to learn new skills within the curriculum. This takes on many elements of games, as many games allow you to progressively learn new skills in a similar fashion. This also allows the user to focus on the task at hand and not be overwhelmed with the rest of the curriculum. Studies on it’s gamification features showed that it proved to be very effective in motivating the user and keeping the user engaged. (Hyunh & Iidai, 2017)

### 2.1.2. Technology – Duolingo

The app was built on amazon web services, python was used for the back-end and jQuery, backbone.js, and Bootstrap were used for the front-end experience. In more recent years, React and redux were primarily used for the front-end.

## 2.3. Interactive Online Learning

Moving beyond the passive one-way nodes of reading, hearing, and viewing static content, interactive online learning requires going beyond the passive one-way nodes of reading, listening, and watching static content. Rather than waiting for information and digesting it, you may pluck out the exact stuff you want and manipulate it. (Cujba, 2020)c

Interactive content responds to both your explicit and inferred requirements while remaining really interactive. Video games, high-fidelity simulations, immersive lessons, problem sets, and other types of content are examples of this type. What makes this type of content interactive in the first place? They synthesise variables based on learners' behaviour at each step and respond appropriately.

To really understand the benefits of interactive online learning, there has been an increasing number of papers published regarding the effectiveness of interactive online learning.

### 2.3.1. Effectiveness of Interactive Online Learning

There are several studies on the effectiveness of online learning. The reason these specific papers were reviewed is because the system aims to be an effective interactive learning website for all users.

Some specific papers regarding the effectiveness of online learning were reviewed. Chingos (Chingos et al, 2016) and Bowen (Bowen et al, 2013) report their findings on the impact of student outcomes of hybrid courses compared to traditional courses. The hybrid courses contained material from existing interactive online courses, meaning that part of the course was replaced with the online material. Leslie (Leslie et al, 2015) comments on their findings of enhancing the online learning experience with an interactive virtual classroom. The architecture of the virtual interactive classroom was based on current pedagogical best practises in higher education. The study done by Lee & Ko (Lee & Ko, 2015) compares the successfulness of different interactive online resources for learning how to code.

**Student Learning Outcomes**

Chingos et al (2016) and Bowen et al (2013) examined the performance of students in hybrid and traditional courses.

Students on the hybrid course did equally well as students on the regular course and spent much less time on the course, according to the findings. This shows that a student is able to learn just as effectively on an interactive online course compared to learning through more traditional means. These papers are relevant to this project as the system aims to add more interactive elements to a subject matter that is mainly taught with limited interactivity with the relevant users.

**Learning Experience**

During the study done by Leslie et al (2015) 144 nurse students were introduced into two online units using the interactive classroom. Students were encouraged to participate actively in online learning in the classrooms. The classroom experience received overwhelming positive response from participants, particularly in regards to its participatory character, blended learning approaches, and user-friendliness.

The interactive and blended learning components were highly regarded by students, as they are associated with successful learning, student happiness, and retention. This paper is very relevant to the system as the main users of this system will likely be taught material regarding the Raspberry through online learning with limited interactivity, this system aims to add lots of interactive elements to online learning while attempting to achieve similar levels of learning experience for all users.

**Successfulness of Interactive Learning Resources**

During the study done by Lee & Ko (Lee & Ko, 2015), the performance of sixty novices was measured using a pretest – postest design, they were assigned to one of the three interactive learning activities; complete a python course on codeacademy, play through a debugging game called Gidget or use Gidgets puzzle designer to write programs from scratch.

It was found that those completing the Codecademy course and those playing through the Gidget game showed over a 100% increase in correct answers when comparing their post-test exam scores to their pre-test exam scores. Those playing Gidget, however, achieved these same learning gains in half the time. This contrasted with novices that used the puzzle designer, who did not show any measurable learning gains. This study is relevant to the system as the system takes features from both Codeacademy and Gidget and aims to achieve the same level of success that participants of this study achieved in regards to success of learning.

## 2.4. Gamification of Interactive Online Learning

Gamification is described as the technique of adding (motivational) affordances to services in order to create game-like experiences and improve behavioural outcomes. (Hamari et al, 2014) My interactive website will contain some gamified features to allow for enhanced user engagement.

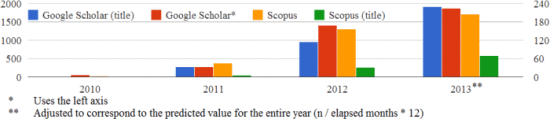
Gartner (Gartner, 2011) predicts that in the years to come more than half of the firms that oversee translating new/known ideas into marketable solutions would have gamified portions of their operations.

Furthermore, an increasing number of successful businesses are focusing their entire service on adding game-like elements to their main operation (for example, Codecademy, a website whose service is to teach users how to code by using game-like elements) or assisting more conventional companies by gamifying their service (for example, Tremendous). (Hamari et al, 2014)

### 2.4.1. Gamification Promotes User Engagement

In recent years gamification is often regarded as an excellent approach of marketing and customer engagement. (Hamari et al, 2014)

The increased interest in gamification among the general public is reflected in the rapid rise in number of papers published on the subject. As seen in the figure below:



*figure 1.6 - increasing no. Of papers on Gamification, (Hamari et al, 2014)*

The study conducted by Montola et al (Montola et al, 2009) - “applying game achievement systems to enhance user experience in a photo sharing system”, reported that all participants had positive experiences regarding the gamification features in the form of engagement and enjoyment. Other studies also reported similar findings. (Dong et al, 2012) (Li et al, 2012) (Hamari et al, 2014).

Gamification's learning outcomes have been mainly favourable in research in education/learning contexts, such as improved motivation and engagement in learning tasks. One such study was conducted by Hakulinen et al (Hakulinen et al, 2013) where they studied the effect of achievement badges in online learning environments, other studies also reported similar findings. (Domínguez et al, 2013) (Dong et al, 2012) (Hamari et al, 2014)

## 2.5. React.js & Angular.js on Interactive Websites

In this section of the report a discussion of two effective framework solutions will be conducted -that would be applicable to this project, the frameworks are react and angular. (Saks, 2019) An explanation of the advantages and drawbacks of each framework will be conducted.

### 2.5.1 React.js

As stated on the official React.js website, “React.js is a Javascript library for building user interfaces”. React is a user interface library created by Facebook to make it easier to create interactive, stateful, and reusable UI components. It is utilised at Facebook. ReactJS excels at rendering complex user interfaces in a fast and efficient manner. (Kumar & Singh, 2016)

ReactJS has the advantage of being considerably easier to learn and use. It includes a lot of documentation, tutorials, and training materials. Any developer with JavaScript experience can quickly learn React and start building web apps in a matter of days. Furthermore, creating a dynamic web application primarily with HTML strings was difficult due to the complicated coding required, but React JS eliminated that problem and made it easy. It required less coding while providing more functionality. (Graziotin et al, 2011)

A drawback of React is that it needs to rely on other technologies as React only covers the UI layers of the system. Additionally as React uses JSX - a syntax extension that allows Javascript and HTML to be used in tandem, this can be drawback if one is not familiar with JSX due to its steep learning curve.

#### 2.5.1.1. Interactive Applications that utilise React.js

While duolingo’s front-end was initially written on Backbone.js and Mustache, now it is mostly on react and redux, according to a case study aws conducted in 2016. (AWS, 2016) Duolingo is the most popular language learning app in the world, utilising gamification to make the Duolingo application feel like a game as users learn.

### 2.5.2 Angular.js

AngularJS (Оглукян, 2015) is a Google-maintained open source JavaScript framework that can assist developers in creating single-page apps. Developers' lives are made much easier by AngularJS, which is built on top of JavaScript. The goal of adopting AngularJS in your web application is to make it modular and simple to maintain.

An advantage of Angular is the versatility of Angular capabilities, such as template syntax, Angular CLI, routers, and others this make’s the work of the programmer to be simpler and enable speedy loading of the application. To efficiently display obtained data in the UI, the framework is compatible with a variety of back-end programming languages. Furthermore, angular is excellent for cross-platform development. (Shybeko, 2021)

An issue with angular is that it has quite a steep learning curve, due to having limited experience and time this may be an issue. Additionally, it is quite a complex and verbose framework, therefore making it not suitable for smaller systems. (Delsev et al, 2018)

#### 2.5.2.1. Interactive Applications that utilise Angular.js

There are many interactive applications built using Angular, such as Upwork, It is widely regarded as the world's largest and most popular freelancing and business marketplace. For all recruiting needs, Upwork links freelancers, agencies, and independent workers with businesses of all sizes. Additionally paypal is also made with angular, the money transfer business that many people use regularly.

## 2.6. Login and Security Features

As this project aims to implement appropriate login and security features this section discusses both topics in more detail and discusses the relevance of them to the system to be developed.

Making an effective login page requires certain features to be present. An article by uxforthemasses describes many desirable features such as: making it clear where to login, separating login and registration, allowing users to login with a 3rd party account etc…

Logging in securely is a requirement for every website, there are many published papers on methods to be able to login securely (Rahim et al, 2020) (Li et al, 2021) – this is a vital process as logging in requires a users identification and authentication. And if the login page is not secure this can easily become a major issue resulting in vulnerabilities in your system that can be taken advantage of from malicious hackers etc.

# 3. Requirements Analysis

## 3.1 Stakeholder Analysis

The stakeholders of this project have been identified in this section and have been considered

throughout the project.

The main stakeholders for this application are any individuals that are interested in learning more about the Raspberry Pi. The design of this application will allow for users to gain a solid understanding of the Raspberry Pi without the need to own one.

Valued stakeholders of this website will be computer science undergraduates or others in similar degrees, where they will more than often need to work with a Raspberry Pi at some point.

## 3.2 Approach

As mentioned in Chapter 1.1 (Aims), the main aim of this project is to develop an interactive gamified online learning application to teach users the fundamentals of the Raspberry Pi and some python projects they can perform on a Raspberry Pi. In order to achieve this aim, a group of objectives are outlined in the following chapter 1.2 (Objectives). To make sure the aims and objectives of this system are completed, requirements for this particular system were produced and put into two separate categories: functional and non-functional requirements. These requirements will be prioritised using the MoSCoW method. These requirements will be tested, more details can be found in the evaluation section.

Due to the complexity of this project, that has various aims and objectives, the overall system was split into six separate systems, this is to create more concise requirements. The hierarchy of the system is shown and explained below.

**The System Hierarchy**   
1. The RPL (Raspberry Pi Learning) System

1.1 The L/R (Login/Registration) System  
 1.2. The Course System   
 1.2.1. The ITP (Introduction to Raspberry Pi) Course System   
 1.2.2. The PS (Python Projects on Raspberry Pi) Course System

The system called “RPL” responsibility lies within the entire system. Within the RPL System, we have the subsystem “The Login/Registration System” which is responsible for handling the operation of a user logging into the system/registering, this is required as each user needs to be able to be uniquely identified to allow the system to track how much of the course they have done etc... Additionally, there is the subsystem “The Course System” that’s responsible for every course and includes  
requirements every course shares. Within the “Course System”, there are subsystems   
for the individual courses as each course may have unique requirements to itself.   
**MoSCoW Priority**

All the requirements have been given a priority through the application of the MoSCoW method (Khan et al, 2015), every requirement will have one of these priorities: M (Must), S (Should), C (Could) or W (Will Not).

## 3.3. Functional Requirements

**Functional Requirements 1 – The L/R (Login/Registration) System**

|  |  |  |
| --- | --- | --- |
| **ID** | **Description** | **Priority** |
| FR1-1 | The L/R System will allow users that would like to register to the system can register with an email and password. | M |
| FR1-2 | The L/R System will make sure that an e-mail address will only be able to register a single account. | M |
| FR1-3 | The L/R System will make sure all accounts require a unique username to be set. | M |
| FR1-4 | The L/R System will make sure the inputted password must be 8 characters in length and include at least one special character and one number. | M |
| FR1-5 | The L/R System will make sure that all details entered for registration will be kept secured in a database. | M |
| FR1-6 | The L/R System will make sure users will be able to login via their own email and password, they will also be able to logout. | M |

**Functional Requirements 2 – The RPL (Raspberry Pi Learning) System**

|  |  |  |
| --- | --- | --- |
| **ID** | **Description** | **Priority** |
| FR2-1 | The RPL system will permit users to interact with the system via a web interface. | M |
| FR2-2 | The RPL system will permit every user access to the “Setting up Raspberry Pi” course. | M |
| FR2-3 | The RPL system will permit every user access to the “Raspbian OS” course. | C |
| FR2-4 | The RPL system will permit every user access to the “Python Projects on Raspberry Pi” course. | W |
| FR2-5 | The RPL system will allow users to be redirected to a page contained in the website when requested. | M |

**Functional Requirements 3 – The Course System**

|  |  |  |
| --- | --- | --- |
| **ID** | **Description** | **Priority** |
| FR3-1 | The Course System will display to users an introduction of the course when a user starts one. | M |
| FR3-2 | The Course System will display the entire course in a series of bite-sized chapters for the user to complete in order. | M |
| FR3-3 | The Course System will display to the user whether they got the answer to the exercise correctly after they click the “Submit” button. |  |
| FR3-4 | The Course System will allow users to view the solution to the answer via a “View Solution” button after they have pressed “Submit” twice and have inputted wrong answers both times. | M |
| FR3-5 | The Course System will display a “Next Question” button if the user has successfully answered the exercise correctly. | M |
| FR3-6 | The Course System will display a “Next Question” button if the user has clicked on the “View Solution” button. | M |
| FR3-7 | The Course System will display a “Next Course” button if the user is on the final chapter of the course and has just successfully answered all questions correctly in the chapter. | M |
| FR3-8 | The Course System shall allow users to see there progression of the course via a percentage displayed on the course page. | M |
| FR3-9 | The Course System will reward users with EXP every time they complete a chapter of the course, after gathering enough EXP a users level will increase. | M |
| FR3-10 | The Course System will display the users level and name. | M |
| FR3-11 | The Course System will grant more EXP to all the users the less questions they get wrong. | C |

**Functional Requirements 4 – The ITP (Introduction to Raspberry PI) System**

|  |  |  |
| --- | --- | --- |
| **ID** | **Description** | **Priority** |
| FR4-1 | The ITP System will allow users to interact with an interactive online Raspberry Pi that aims to mimic the feel of a real Raspberry Pi throughout the course. | M |
| FR4-2 | The ITP System will display a “View Raspberry Pi” button in every exercise that brings up the interactive Raspberry Pi. | M |
| FR4-3 | The ITP System will display basic relevant information about the different sections of the interactive Raspberry Pi when a user hovers over the specific section. | M |
| FR4-4 | The ITP System will allow users to enter the answers to the exercise via a text box. | M |
| FR4-5 | The ITP System will clearly explain how to answer the exercise if the way to answer it differs from the usual text box. | M |
| FR4-6 | The ITP System will display an error if the user answered the question incorrectly. | M |
| FR4-7 | The ITP System will allow users to interact with a make-shift version of Raspbian OS that aims to mimic the feel and some very basic functionality of the OS. | M |
| FR4-8 | The ITP system will allow users to interact with the make-shift Raspbian OS in some of the chapters regarding Raspbian OS. | M |
| FR4-9 | The ITP System will explain to all users how to use the make-shift Raspbian OS to answer the exercises that utilise it. | M |

**Functional Requirements 5 – The PS (Python Projects on the Raspberry Pi) System**

|  |  |  |
| --- | --- | --- |
| **ID** | **Description** | **Priority** |
| FR5-1 | The PS System will allow the user to practice the relevant python needed to answer the exercises following it to all users. | M |
| FR5-2 | The PS System will have exercises where the user answers the question by dragging the correct answers into the box/boxes from the ones provided. | M |
| FR5-3 | The PS System will further develop from the interactive Raspberry Pi/Raspbian OS to allow for a fully interactive experience while covering the python projects throughout the course. | C |
| FR5-4 | The PS System will attempt to mimic the experience of setting up Python Projects within the relevant chapters of the course. | C |
| FR5-5 | The PS System will display a hint on how to answer the exercise if the user answers a question incorrectly. | M |

## 3.4. Non-Functional Requirements

**Non-Functional Requirements 1 – Accessibility**

|  |  |  |
| --- | --- | --- |
| **ID** | **Description** | **Priority** |
| NFR1-1 | The RPL System will make sure that all content not in text form will have a text alternative. (e.g. Images will have a text alternative) | S |
| NFR1-2 | The RPL System will make sure that there will be a text alternative for information conveyed with colour. (e.g. error messages that are coloured red will also use the word “error”) | S |
| NFR1-3 | The RPL System will make sure that the system has no loss in content or functionality even if the user zooms in by 200% | S |

**Non-Functional Requirements 2 – Compatibility**

|  |  |  |
| --- | --- | --- |
| **ID** | **Description** | **Priority** |
| NFR2-1 | The RPL System will be compatible on all major web browsers, this includes: Google Chrome. Mozilla Firefox, Opera, Microsoft Edge and Safari. | M |
| NFR2-2 | The RPL System will be compatible on devices of varying sizes using responsive web elements. | M |

**Non-Functional Requirements 3 – Usability**

|  |  |  |
| --- | --- | --- |
| **ID** | **Description** | **Priority** |
| NFR3-1 | The RPL System will allow users of any literacy level to be able to use and understand the system. | M |
| NFR3-2 | The RPL System will make sure any page on the website is rendered in under three seconds. | M |
| NFR3-3 | The RPL System will make sure that any page of the website becomes fully interactive within two seconds of when it is requested. | M |
| NRF3-4 | The RPL System will provide the user with helpful documentation on how to use the system when they press the “Help” button. | M |

# 4. Evaluation Analysis

In this chapter I will first objectively evaluate the new website against the system requirements to determine if the website meets the desired specification. I will then evaluate my project’s schedule by comparing the actual time spent on each stage to my original plan, and explaining why any notable disparities occurred. Lastly, I will evaluate the responses I received from my final usability study regarding effectiveness of the interactive elements of the system and if the gamification elements improved user engagement. The combination of these three evaluations will identify any changes that could be made to the system to improve it.

# 5. Project Management

## 5.1. Project Schedule – Initial Gantt Chart

Chart

Description automatically generated

## 5.2. Risk Analysis

In this section, the risks pertaining to the project will be identified and it will be stated what the mitigation steps are.

|  |  |  |  |
| --- | --- | --- | --- |
| **Risk** | **Description** | **Impact** | **Probability** |
| Design is unattainable | The Design of this project is unable to be completed within the given time. | High | Low |
| Requirements of the project are misunderstood | The system created does not match the original specification given. | High | Low |
| Backup lost | The backup of the documents/code of this project were deleted from the cloud and/or personal pc. | High | Low |
| Chosen technologies are suboptimal | The technologies chosen are poorly document or do not function as expected. | Medium | Medium |
| Security Risks | Loss of code/data due to being hacked or thievery of some sort. | Low | High |
| Project is too difficult | The project scope was set too large and the features of the system are unable to be completed within the allotted timeframe. | Medium | Medium |
| Project is too easy | The developmental process of the system is completed well ahead of the allotted time. | Medium | Low |
| Illness | Falling behind schedule due to getting ill | Low | High |
| Overestimation in ability | Falling behind schedule due to not correctly analysing my skills and qualities. | Low | Medium |

#### 5.2.1 Risk Mitigation

|  |  |  |  |
| --- | --- | --- | --- |
| **Risk** | **Description** | **Type** | **Strategy** |
| Design is unattainable | Look back at the requirements and find the faults within the design in order to create an attainable design. | Organisational | Contingency |
| Requirements of the project are misunderstood | Discuss the requirements of the system with supervisor before development to reduce any unnecessary development. | Requirements | Avoidance |
| Backup lost | Have several backups of the code/documents. | Technological | Avoidance |
| Chosen technologies are suboptimal | The technologies chosen are poorly document or do not function as expected. | Technological | Avoidance |
| Security Risks | Setup any necessary security countermeasures on the network/databases that is used for the project. | Technological | Avoidance |
| Project is too difficult | Discuss the feedback received from your supervisor and second reader and adjust the scope of the project appropriately. | Organisational | Avoidance |
| Project is too easy | Create several hard optional requirements. | Organisational | Avoidance |
| Illness | If illness is severe enough discuss with supervisor about submitting necessary MC form. | Personal | Contingency |
| Overestimation in ability | Discuss with supervisor for advice if struggling with some specific technologies. | Personal | Minimisation |

## 5.3. Professional, Legal, Ethical and Social Issues

### 5.3.1 Ethical Issues

An ethical issue that applies to this project is concerned with the usability study that will be conducted - as this study requires the use of participants in order to interact with the website and then fill out a questionnaire. Heriot Watt University has classed this project as an "interface only" usability study, which means that the questionnaire has been approved and consent forms will be handed out to all participants to fill out. The consent form can be found in appendix A.

### 5.3.2 Legal Issues

The main legal issue with this project pertains to the Copyright, Designs and Patents Act 1988. This is because the Raspberry Pi is a trademarked brand and they have specific guidelines in place to use there brand for genuine services.

As stated on there website the use of the word “Raspberry Pi” is referred to as “Raspberry Pi Word Mark”, the only times you may use the Raspberry Pi Word Mark is stated as:

(i) to refer to or describe genuine Raspberry Pi products or services; or

(ii) to state or indicate that another product is compatible with, works with or can be used with our products.

As the website will constantly use the Raspberry Pi Word Mark under the two conditions stated above there will be no issues.

# 6. References

* Amazon Web Services, Inc. 2021. *Duolingo Case Study-DynamoDB Case Study*. [online] Available at: <https://aws.amazon.com/solutions/case-studies/duolingo-case-study-dynamodb/> [Accessed 9 November 2021].
* *International Journal of Latest Trends in Engineering and Technology*, 2016. Comparative analysis of angularjs and reactjs. 7(4).
* Reactjs.org. 2021. *React – A JavaScript library for building user interfaces*. [online] Available at: <https://reactjs.org/> [Accessed 9 November 2021].
* GmbH, L., 2021. *Defining the innovation process.*. [online] Lead-innovation.com. Available at: <https://www.lead-innovation.com/en/innovation-process> [Accessed 9 November 2021].
* J. Hamari, J. Koivisto and H. Sarsa, "Does Gamification Work? -- A Literature Review of EmPirical Studies on Gamification," 2014 47th Hawaii International Conference on System Sciences, 2014, pp. 3025-3034, doi: 10.1109/HICSS.2014.377.
* S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: defining gamification,", In Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, September 28-30, 2011, Tampere, Finland, ACM, pp. 9-15.
* J. Hamari, and V. Lehdonvirta, "Game design as marketing: How game mechanics create demand for virtual goods,", International journal of business science and applied management, 5(1), 2010, pp. 14-29.
* K. Huotari, and J. Hamari, "Defining gamification: a service marketing perspective,", In Proceedings of the 16th International Academic MindTrek Conference, October 3-5, 2012, Tampere, Finland, ACM, pp. 17-22.
* G. Zichermann, and C. Cunningham, Gamification by design: Implementing game mechanics in web and mobile apps, Sebastopol, CA, O'Reilly Media, 2011.
* Gartner, "Gartner says by 2015, more than 50 percent of organizations that manage innovation processes will gamify those processes,", http://www.gartner.com/newsroom/id/1629214, April 12, 2011.
* M. Montola, T. Nummenmaa, A. Lucero, M. Boberg, and H. Korhonen, "Applying game achievement systems to enhance user experience in a photo sharing service,", In Proceedings of the 13th International MindTrek Conference: Everyday Life in the Ubiquitous Era, September 30 - October 2, 2009, Tampere, Finland, ACM, pp. 94-97.
* T. Dong, M. Dontcheva, D. Joseph, K. Karahalios, M.W. Newman, and M.S. Ackerman, "Discovery-based games for learning software,", In Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems, May 5-10, 2012, Austin, Texas, USA, ACM, pp. 2083-2086.
* W. Li, T. Grossman, and G. Fitzmaurice, "GamiCAD: a gamified tutorial system for first time autocad users,", In Proceedings of the 25th annual ACM symposium on User interface software and technology, October 7-10, 2012, Cambridge, Massachusetts, USA, ACM, pp. 103-112.
* X. Pham, T. Nguyen, W. Hwang and G. Chen, "Effects of Push Notifications on Learner Engagement in a Mobile Learning App," 2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT), 2016, pp. 90-94, doi: 10.1109/ICALT.2016.50.
* Shahzad, F., Sheltami, T., Shakshuki, E. and Shaikh, O., 2016. A Review of Latest Web Tools and Libraries for State-of-the-art Visualization. *Procedia Computer Science*, 98, pp.100-106.
* Upton, E. and Halfacree, G., 2012. *Meet the Raspberry Pi*. John Wiley & Sons.
* Donat, W. and Krause, C., 2014. *Learn Raspberry Pi Programming with Python*. New York, NY 10013: Apress.
* Monk, S., 2013. *Programming the Raspberry Pi: getting started with Python* (p. 192). Mcgraw-hill.
* Richardson, M. and Wallace, S., 2014. *Getting Started with Raspberry Pi: Electronic Projects with Python, Scratch, and Linux*. Maker Media, Inc..
* Saks, E., 2019. JavaScript Frameworks: Angular vs React vs Vue.
* Delcev, S. and Draskovic, D., 2018, May. Modern JavaScript frameworks: A survey study. In *2018 Zooming Innovation in Consumer Technologies Conference (ZINC)* (pp. 106-109). IEEE.
* Seaborn, K. and Fels, D.I., 2015. Gamification in theory and action: A survey. *International Journal of human-computer studies*, *74*, pp.14-31.
* Harrington, W., 2015. *Learning raspbian*. Packt Publishing Ltd.
* Shybeko, A., 2021. *8 Benefits of Angular for Your Project*. [online] Light-it.net. Available at: <https://light-it.net/blog/8-advantages-of-angular-for-businesses-and-developers/> [Accessed 19 November 2021].
* Graziotin, D. and Abrahamsson, P., 2013, June. Making sense out of a jungle of JavaScript frameworks. In *International Conference on Product Focused Software Process Improvement* (pp. 334-337). Springer, Berlin, Heidelberg.
* Fahy, P.J., 2008. Characteristics of interactive online learning media. *The theory and practice of online learning*, p.167.
* Akpan, I., Marshall, P., Bird, J. and Harrison, D., 2013, April. Exploring the effects of space and place on engagement with an interactive installation. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 2213-2222).
* Cujba, S., 2020. *Interactive Online Learning: Meaning, Principles, Examples.*. [online] Raccoongang.com. Available at: <https://raccoongang.com/blog/interactive-online-learning-meaning-principles-examples/> [Accessed 21 November 2021].
* McGowan, S., 2021. *UX Case Study: Duolingo*. [online] Usabilitygeek.com. Available at: <https://usabilitygeek.com/ux-case-study-duolingo/> [Accessed 21 November 2021].
* Search Design. 2018. *Duolingo, UX Case Study*. [online] Available at: <https://searchdesign.io/duolingo-case-study/> [Accessed 21 November 2021].
* Duolingo. 2021. *What is Duolingo?*. [online] Available at: <https://support.duolingo.com/hc/en-us/articles/204829090-What-is-Duolingo-> [Accessed 21 November 2021].
* Duolingo. 2021. *Learn a language for free*. [online] Available at: <https://www.duolingo.com/learn> [Accessed 21 November 2021].
* Pi, R., 2021. *Teach, Learn, and Make with Raspberry Pi*. [online] Raspberry Pi. Available at: <https://www.RaspberryPi.org/> [Accessed 21 November 2021].
* Raspbian.org. 2021. *FrontPage - Raspbian*. [online] Available at: <https://www.raspbian.org/> [Accessed 21 November 2021].
* Raspberry Pi. 2021. *What is a Raspberry Pi?*. [online] Available at: <https://www.RaspberryPi.org/help/what-%20is-a-Raspberry-Pi/> [Accessed 21 November 2021].
* Upton, E. and Halfacree, G., 2014. *Raspberry Pi user guide*. John Wiley & Sons.
* Python.org. 2021. *Welcome to Python.org*. [online] Available at: <https://www.python.org/> [Accessed 21 November 2021].
* Pinout.xyz. 2021. *Raspberry Pi GPIO Pinout*. [online] Available at: <https://pinout.xyz/#> [Accessed 21 November 2021].
* Panchaud, K., 2021. *Case study: Duolingo*. [online] Medium. Available at: <https://bootcamp.uxdesign.cc/a-ux-ui-case-study-on-duolingo-9ae6033ff0c> [Accessed 21 November 2021].
* Spool, J., 2009. *The $300 Million Button*. [online] UX Articles by UIE. Available at: <https://articles.uie.com/three\_hund\_million\_button/> [Accessed 21 November 2021].
* Bonnardel, N., Piolat, A. and Le Bigot, L., 2011. The impact of colour on Website appeal and users’ cognitive processes. *Displays*, *32*(2), pp.69-80.
* Huynh, D. and Iida, H., 2017. An Analysis of Winning Streak's Effects in Language Course of" Duolingo".
* Chingos, M.M., Griffiths, R.J., Mulhern, C. and Spies, R.R., 2017. Interactive online learning on campus: Comparing students’ outcomes in hybrid and traditional courses in the university system of Maryland. *The Journal of Higher Education*, *88*(2), pp.210-233.
* Bowen, W.G., Chingos, M.M., Lack, K.A. and Nygren, T.I., 2014. Interactive learning online at public universities: Evidence from a six‐campus randomized trial. *Journal of Policy Analysis and Management*, *33*(1), pp.94-111.
* Leslie, A., Beverley, E. and Sian, M.P., 2015. Enhancing the online learning experience using virtual interactive classrooms. *Australian Journal of Advanced Nursing, The*, *32*(4), pp.22-31.
* Lee, M.J. and Ko, A.J., 2015, August. Comparing the effectiveness of online learning approaches on CS1 learning outcomes. In *Proceedings of the eleventh annual international conference on international computing education research* (pp. 237-246).
* Hakulinen, L., Auvinen, T. and Korhonen, A., 2013, March. Empirical study on the effect of achievement badges in TRAKLA2 online learning environment. In *2013 Learning and teaching in computing and engineering* (pp. 47-54). IEEE.
* Khan, J.A., Rehman, I.U., Khan, Y.H., Khan, I.J. and Rashid, S., 2015. Comparison of Requirement Prioritization Techniques to Find Best Prioritization Technique. *International Journal of Modern Education & Computer Science*, *7*(11).
* Rahim, R., Murugan, S., Mostafa, R.R., Dubey, A.K., Regin, R., Kulkarni, V. and Dhanalakshmi, K.S., 2020. Detecting the Phishing Attack Using Collaborative Approach and Secure Login through Dynamic Virtual Passwords. *Webology*, *17*(2).
* Li, Y., Yun, X., Fang, L. and Ge, C., 2021. An Efficient Login Authentication System against Multiple Attacks in Mobile Devices. *Symmetry*, *13*(1), p.125.
* UXM. 2021. *10 tips for a better login page and process - UXM*. [online] Available at: <http://www.uxforthemasses.com/login-page/> [Accessed 21 November 2021].

# 7. Appendices

## Appendix A – Consent Form

Text

Description automatically generated