Table of Contents

[1 Introduction 1](#_Toc479246131)

[1.1 Aims 2](#_Toc479246132)

[1.2 Personal Motivation 3](#_Toc479246133)

[1.3 Reader’s Guide 3](#_Toc479246134)

[2 Background 4](#_Toc479246135)

[2.1 Effects of Concussion 4](#_Toc479246136)

[2.2 Accessibility 5](#_Toc479246137)

[2.3 Existing Methods of Reporting 6](#_Toc479246138)

[2.3.1 Professional Rugby 7](#_Toc479246139)

[2.3.2 Domestic Rugby 7](#_Toc479246140)

[3 Design 8](#_Toc479246141)

[3.1 Requirements 8](#_Toc479246142)

[3.1.1 Functional Requirements 8](#_Toc479246143)

[3.1.2 Non-functional Requirements 9](#_Toc479246144)

[3.2 Technical Approach 10](#_Toc479246145)

[3.3 Multitier Architecture 10](#_Toc479246146)

[3.4 SDLC Model 12](#_Toc479246147)

[3.5 User Interface 13](#_Toc479246148)

[3.5.1 Mockups 13](#_Toc479246149)

[3.5.2 Reality 13](#_Toc479246150)

[4 Implementation 13](#_Toc479246151)

[4.1 Technologies Used 13](#_Toc479246152)

[4.1.1 MAMP 14](#_Toc479246153)

[4.1.2 000webhost.com & phpMyAdmin 14](#_Toc479246154)

[References 15](#_Toc479246155)

# 1 Introduction

Concussion is one of the most serious injuries in sport. It is an injury to the brain which results in a loss of normal brain function (American Association of Neurological Surgeons, 2017). In the last number of years, it has come to the fore of the media. What makes concussions so alarming to the general public and the wider rugby community is the newly established links between concussions and degenerative brain diseases like chronic traumatic encephalopathy (CTE). This disease has been found in the brains of a number of American football players who died prematurely. Each of the players found to have this disease dealt with a huge number of concussive or sub-concussive blows to the head throughout their playing career. What is scary about this is that American football players (0.2 per 1000 player hours) have a lower rate of reported concussions than professional rugby players (3.9 per 1000 player hours).

Another worrying fact about the reporting of concussion in rugby is the underreporting of mild traumatic brain injuries (MTBI) by players. Per a study of Irish U20 rugby players, the author found that 44% of the players surveyed who had received a concussion over the previous year, had failed to report it (Baker, et al., 2012). Much of this is due to the fact that players don’t want to be seen as weak or they don’t want to let their teammates down by going off with an injury.

Concussion Log is a tool which sets out to deal with this second problem. It allows referees to log onto the system and input the details of a concussion for a match they officiated. Along with this, the tool would help referees of future matches see if a player has completed the Gradual Return to Play (GRTP) Protocol which sets out a period of time a player must take to recover depending on their age. During this time period, a player is not allowed to return to the field of play.

## Aims

When the author started the project my aim was to get a better understanding of how exactly concussion is reported in rugby and to establish a platform by which referees can play their part in making sure that players who have received a concussion don't come back to play before they have successfully completed all of the necessary return to play protocols as outlined by the IRFU’s GRTP guidelines which are put in place for the safety of all those who play the sport in Ireland, both underage and senior.

The website goes some way in helping referees with the aforementioned aims. It does this with the help of the following:

* A database to store the names of player who have received a concussion and the date on which this happened.
* Allows referees to search for specific attributes e.g. player name, club or date, using the search function.
* Referees are allowed edit and delete rows they have submitted.
* Gives quick and easy access to necessary safety documentation for both parents and referees.

## Personal Motivation

The author has an extreme interest in this topic due to the fact that he is an avid rugby supporter and plays for his local club at a senior level. Over the years he has played, he has received several concussions, some of which affected his ability to continue with his normal life in the week subsequent to the injury. This was seen not only in the author but also in a number of other rugby playing friends.

The actions usually taken when a concussion was received was to take a couple of weeks away from full contact rugby before returning. Most of the time this isn't a satisfactory solution as some concussions are much worse than others and the amount of time taken to recover can vary greatly. In the last number of years, the concussion is a huge sticking point for the IRFU and for other country’s governing bodies and for World Rugby in general.

## Reader’s Guide

**Chapter 2: Background**

This chapter looks at the developer’s decision to use a website design for his project rather than a mobile phone application. It also looks at how concussions are currently assessed and reported at both a professional and a domestic level. It also looks at the devastating effects that concussions can have on individuals.

**Chapter 3: Design**

The Design Chapter examines how the developer approached the project from a technical point of view. This chapter looks at the database design, the first mock-ups of the user interface and the software development model used. It also gives the initial requirements that were gathered, which the developer felt were most important.

**Chapter 4: Implementation**

This chapter will give an overview of the technologies and software used to bring the website from the idea stage to its current iteration. It looks at HTML, CSS, PHP, MYSQL and JavaScript as standalone technologies and it examines phpMyAdmin, MAMP, Sublime Text and 000webhost.com as facilitating software.

# Background

This chapter examines the author’s choice to make a website in place of a mobile application. It also looks at how concussions are currently dealt with at both a domestic and professional level and the effects concussion can have on an individual.

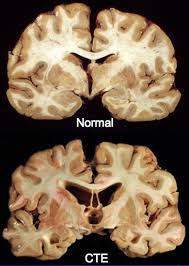
## Effects of Concussion

As previously stated, a concussion is an injury to the brain which results in the temporary loss of normal functionality within the brain (American Association of Neurological Surgeons, 2017). This in a formal medical definition is given as the immediate and transient alteration in brain function, including alteration of mental status and level of consciousness, resulting from machinal force or trauma (American Association of Neurological Surgeons, 2017).

All concussions should be taken seriously, even the effects of a sub-concussive blow can be felt days after. It can affect memory, balance, muscle coordination and speech among other vital actions. Some general symptoms people who have received concussions can have are headaches, nausea, loss of consciousness and changes in mood. They can be seen in both children and adults but sometimes children have more difficulty displaying how they feel (Brainline.org, 2012). Many of these symptoms are evident straight away but some may show hours or even days later. A study conducted by Andrew Mayer at the Mind Research Network in New Mexico found that when the brains of 50 concussion patients were compared with the brains of the same number of healthy people, the concussion patients showed abnormalities four months post-concussion even though they felt better (Mayer, et al., 2013).

The effects of concussion can still be noticed even further along, years even. Per a study by Dr. Maryse Lassonde on the long-term effects of concussion on athletes, she found that “there is abnormal brain wave activity for years after a concussion, as well as the partial wasting away of the motor pathways.” Both of these issues can lead to attention problems in both the short term and long term.

Chronic traumatic encephalopathy is a degenerative brain disease which is found in those who have received a severe blow or repeated blows to the head. It was first found in boxers, from which the term ‘punch drunk’ derives. Initially, the disease was thought to have only been suffered by boxers but with Dr. Bennet Omalu’s findings, further sports and high risk individuals such as military personnel were identified. Below is an illustration of a brain with CTE compared with a normal healthy brain.



Figure

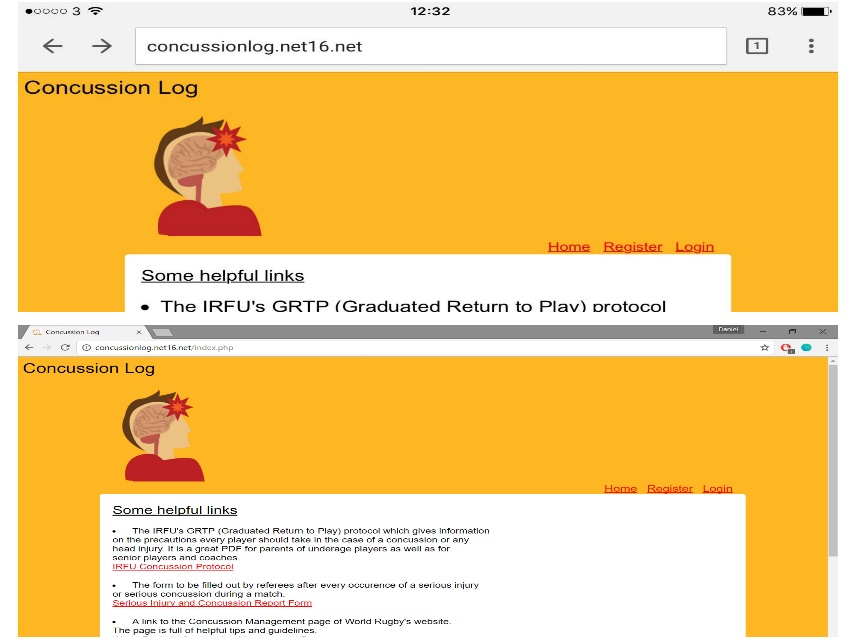
The first case of CTE in an amateur rugby player was documented as recently as 2015 in an Irish man (Stewart, et al., 2016). The disease was confirmed in an autopsy even though the diagnosis was impossible when the patient was alive.

## Accessibility

The developer wanted his project to be accessible by anyone with an internet connection, be it wireless or otherwise, therefore he chose to develop it as a website as opposed to an application only accessible by an iOS or Android device.

To start with the developer chose to host it locally on his device with a backup on his Git repository. To host the database from the get go, the developer used MAMP to make sure his different PHP functions worked locally before going live. 000webhost was chosen as the hosting server as it was free of charge to the developer. It also gives a premium option which would be essential should the traffic and usage of the website increase to beyond the threshold of the free 000webhost product.

As the website is live, it’s not restricted by the type of device used so anyone with a mobile, tablet or computer can access it. The developer made sure that even when someone is using a mobile device, they are able to use all of the functions.



Figure

The top image in Figure 2 is the website as seen in a landscape view on an iPhone 6, while the bottom image is Concussion Log as seen on a laptop screen. On a phone screen it is essential for the text to be bigger so the user doesn’t have to zoom in.

## Existing Methods of Reporting

Like all head injuries, concussions are serious and should be viewed as such by all parties involved. Nowadays, the response to a suspected concussion differs in both the domestic and professional game as there are no head injury assessments (HIA) allowed in domestic rugby. To find out what is exactly involved in both domestic and professional rugby, the author found that he would need to interview a referee. To do this, he would first need to seek approval from the Ethics Committee which is a requirement of Trinity Students. The Application for Ethical Approval can be found in the appendices.

### Professional Rugby

In professional rugby, a HIA is administered to a player where a concussion is suspected. The HIA involves several cognitive, balance and memory tests to assist medics in helping to determine if a player has received a concussion. The number of players who returned to the pitch following a HIA dropped from 56% to 13% (Patricios, et al., 2017) following the introduction of HIAs to the professional game in 2014. Law 3.10 is invoked in professional rugby, mainly to order a player off the pitch for a HIA.

### Domestic Rugby

In domestic rugby where there is no HIA allowed, the duty of care falls on the referee, the player, and coaching staff. In the case where a coach refuses to remove a player from the pitch after the referee advises them to do so, the referee can invoke Law 3.10 which gives the referee the right to “order that player to leave the playing area” (World Rugby, 2017). If this law is invoked, the referee must report the name of the player along with, the name of the coaching staff and the club in his post-match report.

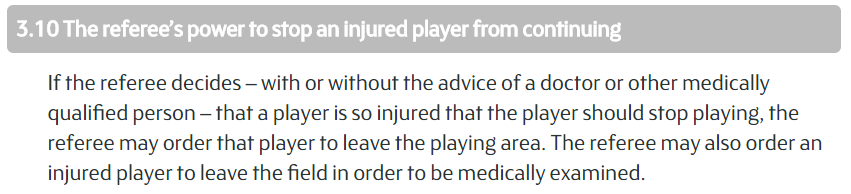


Figure (World Rugby, 2017)

Currently not all suspected concussions are reported by referees. This is because it would be impossible for them to diagnose a concussion themselves as they are not trained medical professionals. Even though it would be impossible for referees in the amateur game to diagnose a concussion, the author believes that a referee should report the incidence of any player leaving the field of play due to a blow to the head.

# Design

This chapter looks at the database design, the first mock-ups of the user interface and the software development model used. It also gives the initial requirements that were gathered, which the developer felt were most important.

## Requirements

A set of functional and non-functional requirements were gathered using the aims mentioned in Chapter 1.

### Functional Requirements

**Log-in System**

Necessary to make sure that there’s a username stamp on every entry to show who is inputting the details of the concussion and to make sure that only the owner of an entry can change or delete it.

**Data Input**

A user should be able to input the information of a new concussion. The input form should be designed in a way which allows completion of the form by the user to be easy and efficient. This will ensure accurate completion of the form and ensure that a full record is added to the database.

**Database Functionality**

The database will be used to store both the details of concussions and user profiles. It is necessary to link the new\_record table in the database to the frontend for the user to see. This database must also be scalable and have the ability to handle many data inputs.

**Eligibility**

Have a function which takes in the age of a player and the number of days since their concussion and return whether they are eligible to play again or not. This function stems from the IRFU’s GRTP Protocol which states that amount of time a player is not allowed play for depends on their age.

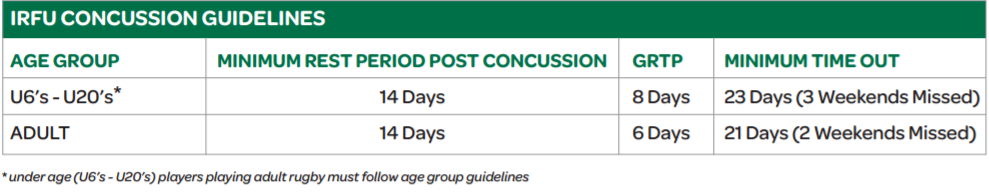


Figure (IRFU, 2013)

**Search**

To decrease the amount of time and effort needed to use the website, a referee should be able to search for specific attributes e.g. player name or club, to make sure that all players are eligible to play a match.

### Non-functional Requirements

The author used a grouping mechanism for his non-functional requirements so that none would be missed. The four groups the author used are: Usability, Reliability, Performance, and Robustness.

**Usability:**

* The author made sure that the website was easy to navigate for the user with everything labelled clearly.
* Making sure that all critical functions were easy to use such as adding a concussion record as well as editing and deleting.

**Reliability:**

* Users to be able to trust the system built by the developer
* The system should run with as little downtime as possible. The author believe 000webhost provides good conditions for the hosting of both the website and database.

**Performance:**

* Website should run smoothly with fast response times no matter how much traffic is on it.

**Robustness:**

* The system should be able to handle all that is asked from it, even from the most inexperienced of users.

## Technical Approach

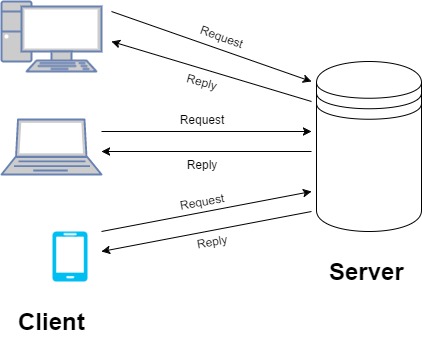
The developer felt the best way to make this project a reality was to develop a website which could be accessed and easily used on both a laptop/desktop and on a mobile/tablet. Using Sublime Text 3 as a text editor, the developer built the website using HTML, CSS, PHP and a small JavaScript script to take the date of concussion into the MySQL database which was made with the helping hand of phpMyAdmin, an open source tool written in PHP which handles the administration side of the MySQL database. MAMP was used initially by the developer when he was searching for a suitable hosting service to use. This tool saved countless hours when building the database in the early stages of the project.

The author made use of a number of learning tools such as Stack Overflow, w3schools.com, and Codecadamy. Much of what the author needed to know about PHP was found using the PHP documentation available online. Unfortunately, as the author only had PHP 5.2 available to him (000webhost haven’t updated their free servers to use newer versions of PHP), he couldn’t use some of the functions found in the newer versions of the scripting language.

## Multitier Architecture

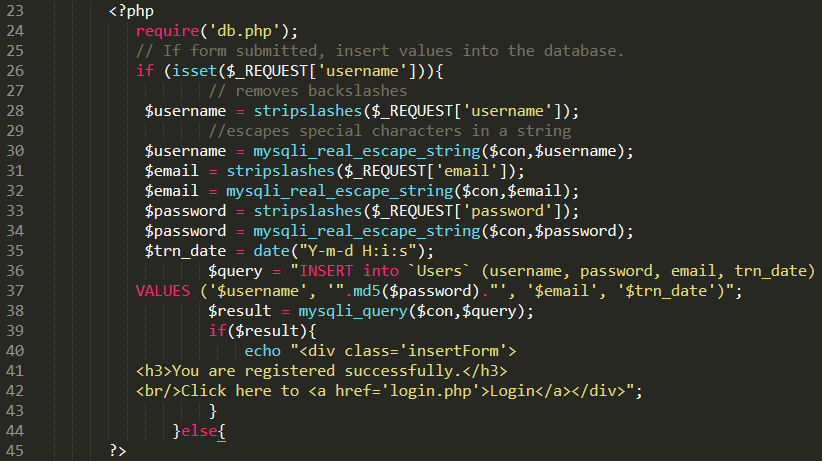
There is currently a two-tier client architecture in use with Concussion Log. This was chosen over the three-tier alternative as there is very little data manipulation being done at present. The data manipulation that is being done though, is being done in the frontend. Refer to chapter on future work for how the author believes this may change.

In two-tier architecture, the direct communication takes place between the client and the server. Unlike three-tier architecture, there is no intermediary between them.



Figure

In the Client Tier, the main part is the user interface which is presented to the client on their screen. The UI was made using HTML, CSS, and JavaScript. The Server Tier is made up of the MySQL database. All the information regarding users and concussions is stored in this database which is why the Server Tier is also sometimes known as the Data Tier. The technology which sends the requests and receives the reply is PHP. Below is a snippet from registration.php which registers a new user. It sends the new user’s details to the server which in turn inserts it into the database and returns that the user has been registered successfully.

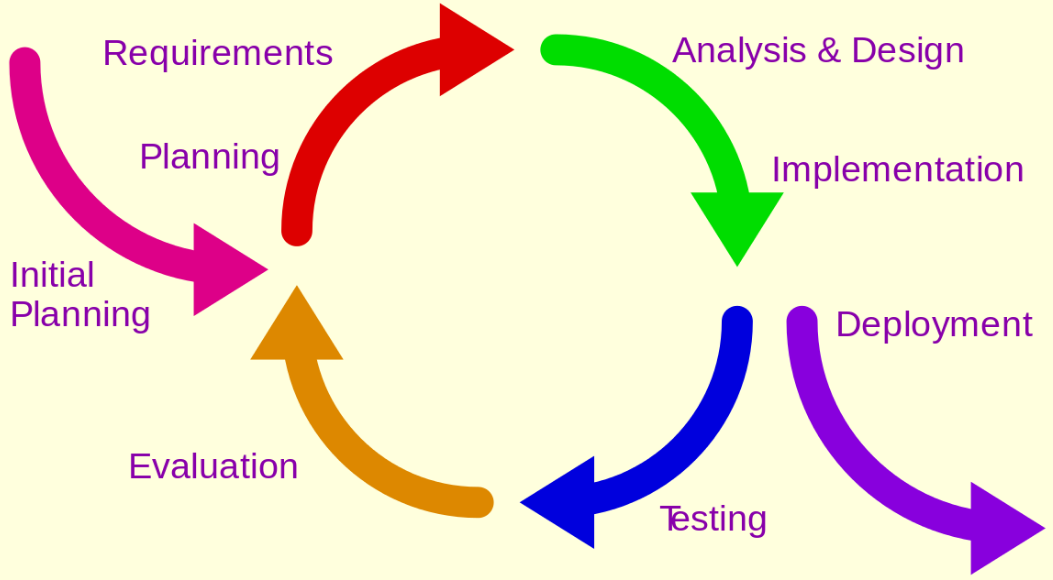


Figure

## SDLC Model

An iterative and incremental model hybrid was used over the course of this project. The developer felt this was the best option as it allowed him to implement new functional capabilities at each version of the website. It also meant he could work around other college assignments and make small changes to his website when he had time.

The major requirements were defined which kept the developer on track throughout. In saying this, some extra functions were added as time went by to make the website more user-friendly and to provide more information for referees when looking to see if players are eligible to play or not.



Figure

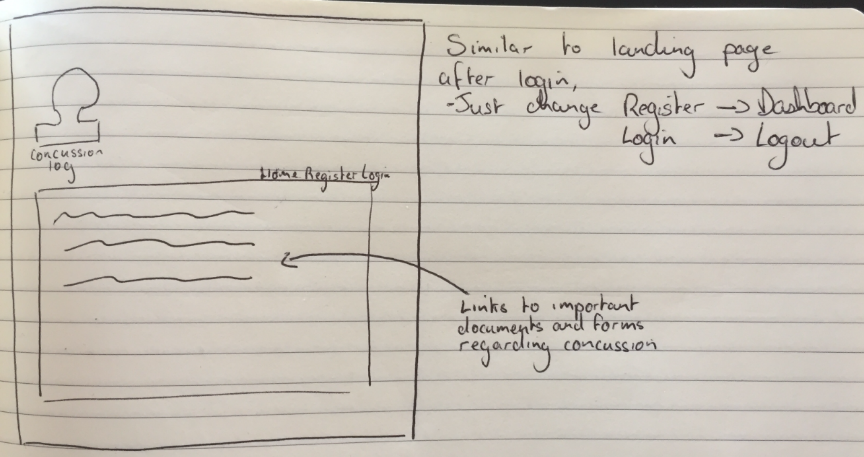
The author found that this model was extremely helpful as there was a working system in place from an early stage in the development of the website. As opposed to the waterfall developmental model where value is only delivered once everything has been completed, this model gave value throughout and allowed backtracking. Along with having a working model quickly in the development lifecycle, debugging was mostly straightforward as it was clear to see if there were any problems as the changes made for each iteration were generally quite small.

## User Interface

The developer set out to produce a UI that was easy to use and helped direct the user all the way from registration to logout and everything in between. For this it needed to be extremely simple with no extraneous function or buttons. For the buttons that were there however, the developer wanted to make sure that they stood out to a user by using contrasting colours and underlined font. One screen mock-up and one screen capture can be found in this section, the rest can be found in the appendices.

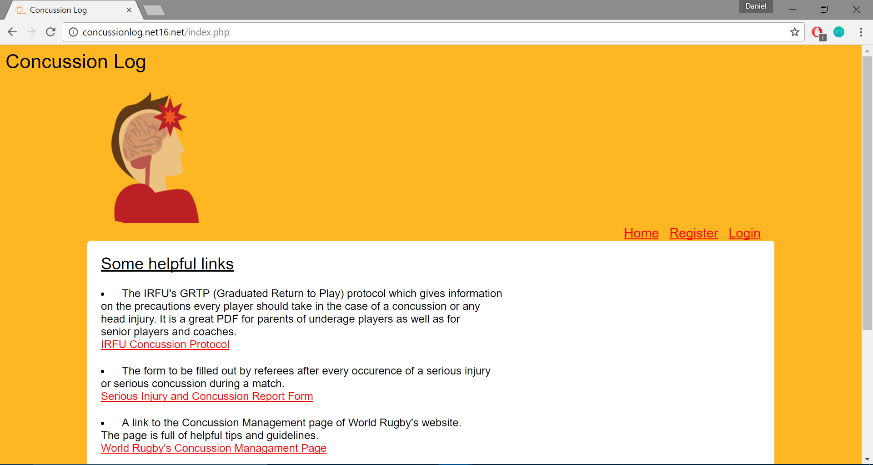
### Mock-ups

In the mock-ups, the developer made a prototype of what he wanted the system to look like at the end of the project. Figure 8 below is a mock-up of the landing page, as can be seen when compared to Figure 9, there is not a huge change.



Figure

### Reality



Figure

# Implementation

**This chapter will give an overview of the technologies and software used to bring the website from the idea stage to its current iteration. It looks at HTML, CSS, PHP, MYSQL and JavaScript as standalone technologies and it examines phpMyAdmin, MAMP, and 000webhost.com as facilitating software.**

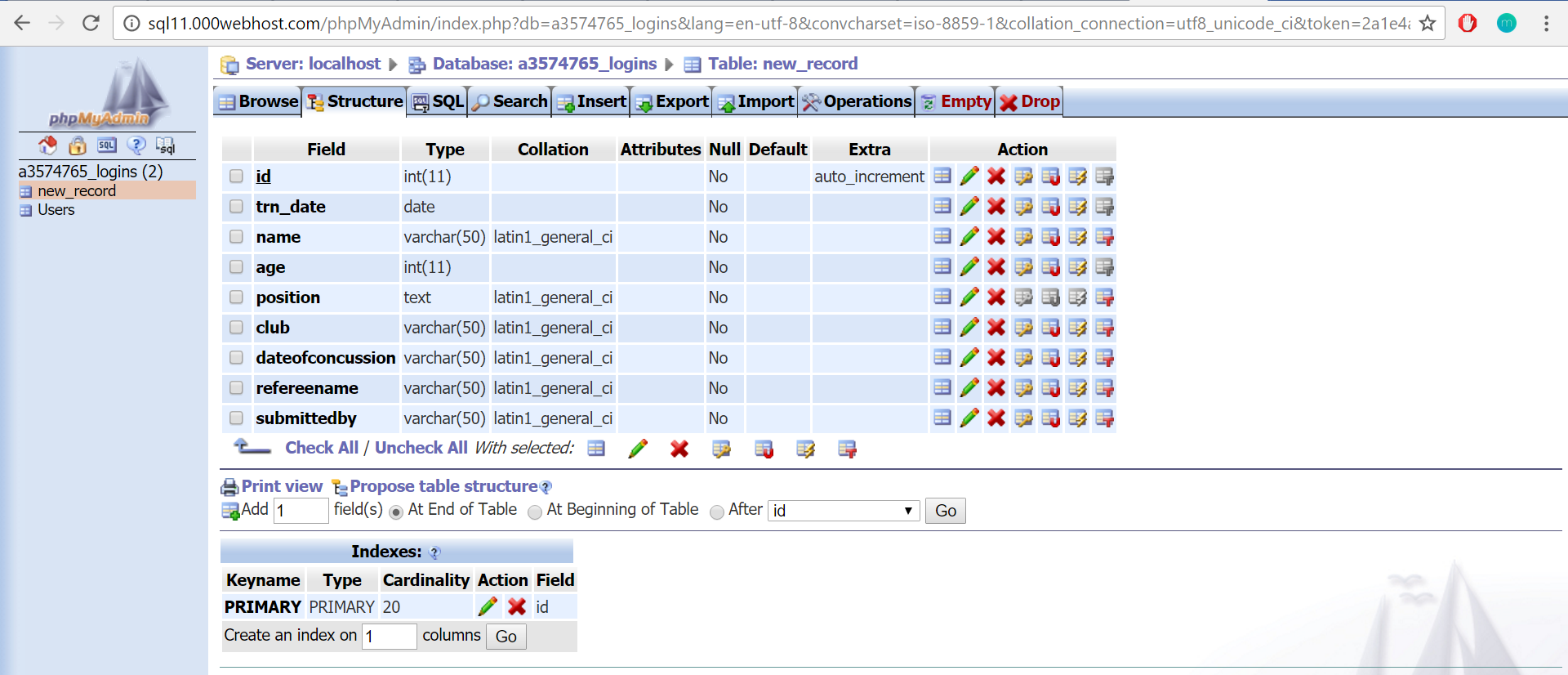
## Technologies Used

### MAMP

MAMP installs a local server environment on your computer. It is a stack which provides the necessary elements of a web server. Within the stack, Apache acts as the web server, MySQL as the database, and PHP as the server side programming language. MAMP itself is designed for use on Mac operating systems but more recently, they released a version for Windows which is what the author used for the purpose of the project.

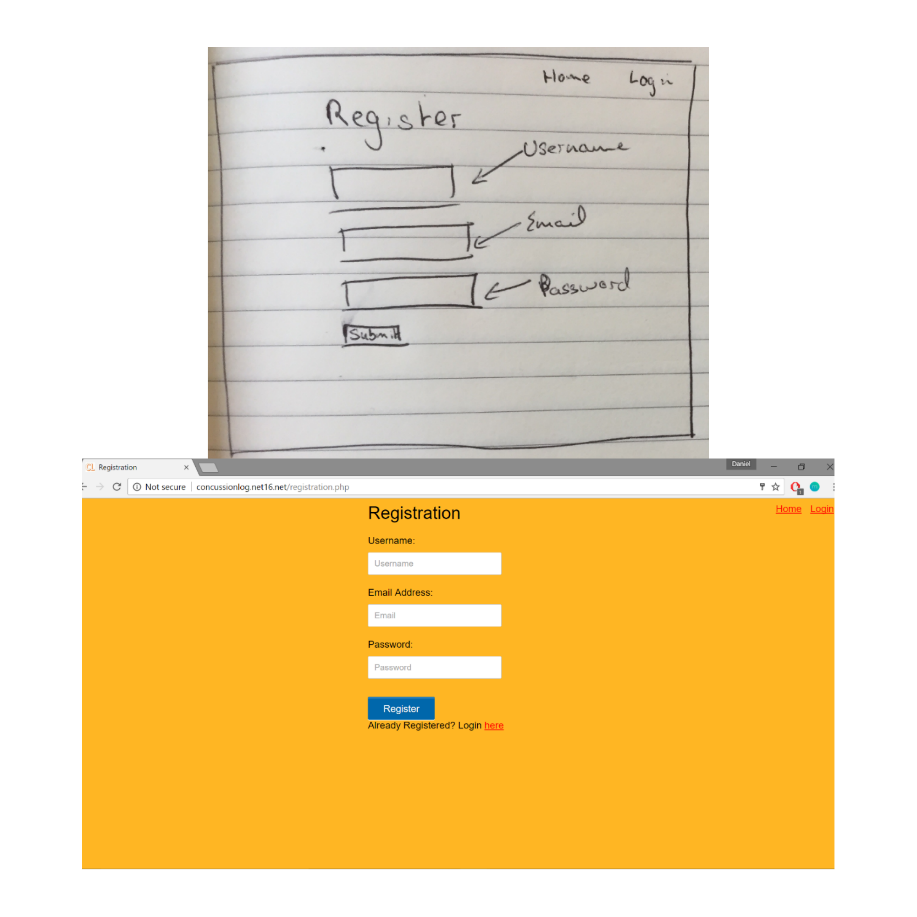
### 000webhost.com & phpMyAdmin

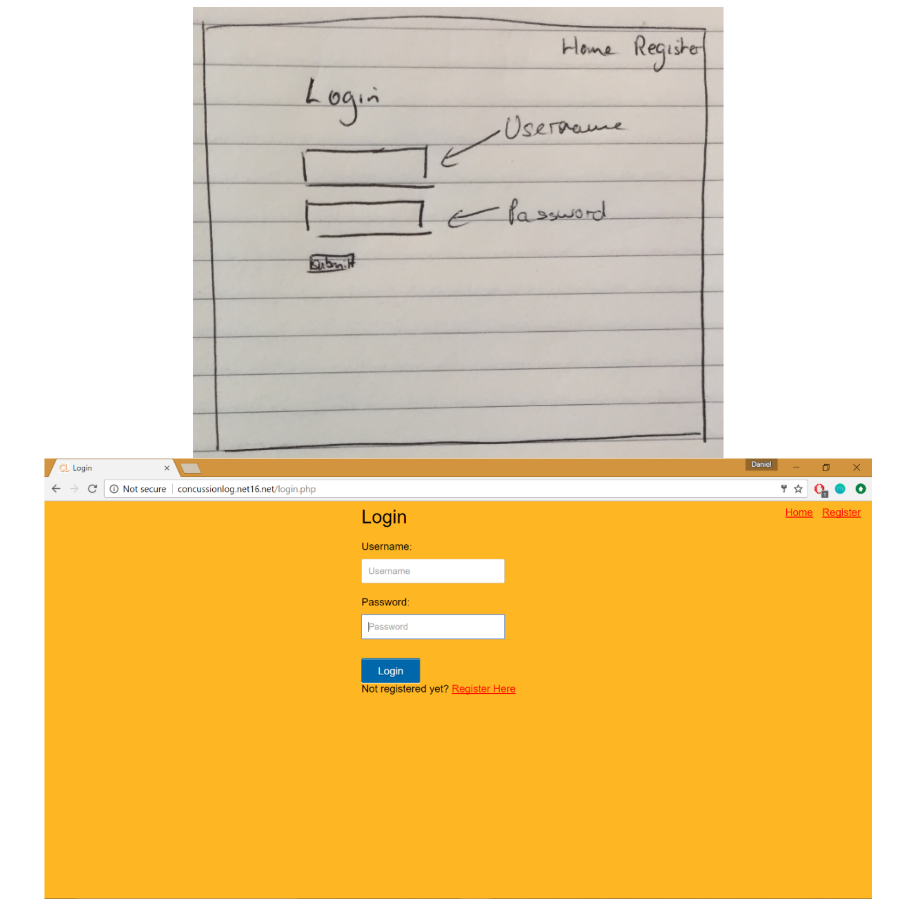
For the project to be brought the author’s laptop to a live working model, the author would need an online host with similar capabilities to what MAMP could offer him. He felt that 000webhost offered him the best free service. He was also familiar with the workings of this service as he had used it as part of a group project previously. 000webhost offered a MySQL database with phpMyAdmin which is where the author built his database which made building and maintaining the database far easier.

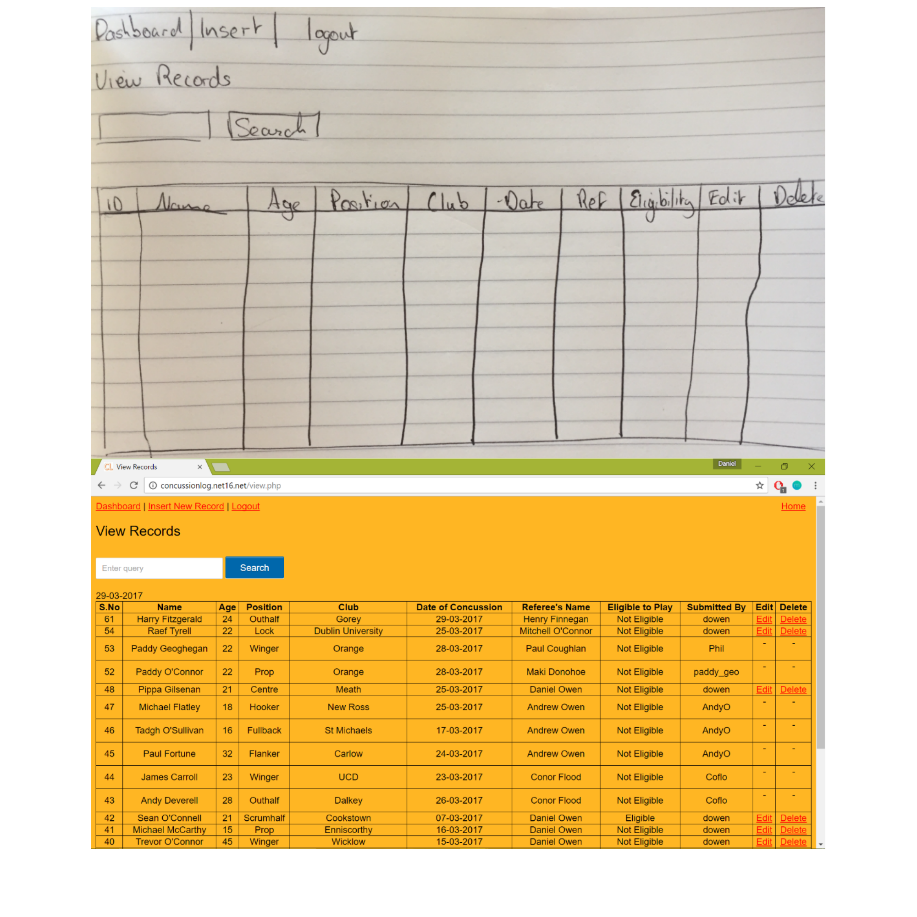


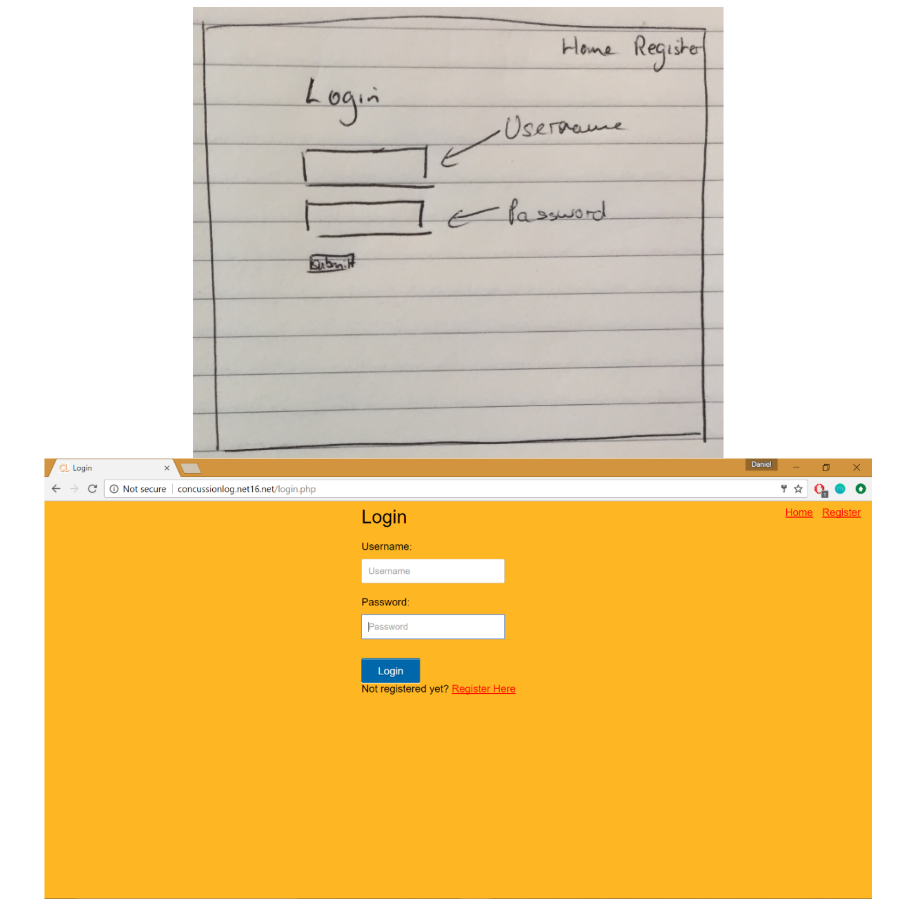
Figure

## Appendices









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