**University of Southern Queensland**

**Faculty of Health, Engineering and Sciences**

# Developing an Activity-Based User Interface for Remote Experimentation for Science Education in Schools

A dissertation submitted by

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# Abstract

As technology continues to expand at an exponential rate our lives become infinitely more connected and complex, this creates an opportunity however, in the form of more highly skilled professional roles on offer. To help address the projected demand in future roles, as well as Australia's deteriorating graduation rate this project will aim to design, develop and evaluate a web-based user interface. The outcomes of this project were two fold; technical work to create the interface and integrate it with pre-existing remote experiments, as well as research based outcomes concerning the various teaching methods, motivations and requirements. As such the evaluation methods for both outcomes will derive a degree of completeness with validation occurring through both the functionality and feel but also in regards to any research results generated. The interface, known as the User Centered Activity System (UCAS) is beginning user testing currently and consists of the base pages required to access and complete activities. It is hoped that this interface will impart the requisite knowledge required for STEM (Science, Technology, Engineering and Mathematics) learning, whilst engaging and encouraging users aided by the addition of game-like elements.

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| GLOSSARY OF TERMS | |
|---|---|
| **Beta Testing** | A testing process software goes through prior to a commercial release |
| **Compiling** | The process of turning one coding language into another that can be read by a computer |
| **Host-side** | Also referred to as 'browser-side' or 'client-side', this term refers to the side the code is compiled on and is in reference to the user side. HTML is compiled client-side and is interpreted by the internet browser application |
| **Server-side** | Referring to code being compiled on the server side, such is the case with PHP |
| **Relational Database** | An organization of databases (tables holding information) that all are related to one another in at least one way, this allows for information to be cross referenced and retrieved between tables |
| **SQL** | Structured Query Language, a coding language with a sole purpose of maintaining, modifying and managing data in a relational database management system. |
| **User** | The physical person using the software, also referred to as a 'client' or 'player |
| **DOCUMENT SPECIFIC TERMS** | |
| **Builder** | This term refers to the process by which a user uploads the functional and descriptive details of an activity using the UCAS. |
| **Maker** | Similar to the Builder, this is a process that allows users to create physical STEM experiments at home and share with the wider community of users online. |
| **Activity** | In regards to this document, an activity is a learning goal which contains a specific purpose. Also referred to as 'quest-based' in terms of gamification. |
| **Experiment** | In regards to this document, an experiment is a physical apparatus that performs user guided or logic control, usually in regards to a certain STEM field. An experiment has no real set goal, it derives it meaningfulness and purpose from being tied to a learning activity. |

# CHAPTER 1 - INTRODUCTION

## 1.1 Overview

As the technology sector exponentially grows, it opens up new possibilities and becomes a much larger part of everyday life innovating communication and entertainment on a world wide scale. In a more complex and entertainment rich world, the onus of learning has, more and more, been passed onto teaching staff. To help accommodate for this, as well as the influx in technical positions that will arise in future years, the University of Southern Queensland (USQ) has created its own remote resource to foster interest and develop practical skills in the largest growing fields; namely science, technology, engineering and mathematics (STEM). To this end, this research contained in this project will endeavour to gauge potential gains, as well as losses, which could be sought from a student undertaking a learning activity using remote resources. These studies, focussing on education, learning, and user accessibility, will also underpin the design and creation of an online learning space that will allow users to access and share experiments that are relatable to real world experiences. This process will be supported by the Remote Access Laboratories for Fun, Innovation and Education (RALfie) team and the associated staff, students, and community members dedicated to its development.

## 1.2 Problem Analysis

Engaging students in a productive and interesting way is the main goal of many education professionals and it has become somewhat apparent that teaching practices could benefit from being altered to suit teaching in a more technological age. A noticeable trend is beginning to appear showing a reduction in Australian students completing tertiary education. This trend coupled with a steady increase in technical and complex careers in all fields has created the requirement for a more active, engaging and gratifying teaching tool. Problems also exist in many rural or small schools where access to expensive equipment to aid in practical experimentation is just not possible; this remote driven project could solve these restrictions to academic material. It is hoped that, in addition to supplementing tertiary learning, this learning tool may also aid in gaining STEM subject interest at the primary and secondary level. As this project focuses on a complex and thoroughly detailed subject matter there will be two sets of related outcomes; one principally to do with the physical work, and also that of the collected and derived research value.

## 1.3 Project Aims

The physical work of the project will come in the form of a designed, developed and validated user interface. This interface, currently known as the User Centered Activity System (UCAS), will be developed through standard web based coding languages and practices. The main purpose of this development is too provide an easy to use and visually appealing platform that would allow user access to remote experiments and activities, many of which are currently underutilised within the USQ's Remote Access Laboratory (RAL). From this it can be concluded that a major aim of this work is the implementation of two web pages that are to form the basis of access that is user authentication and activity selection. Further project aims, derived more from research and the design imperatives set down by the RALfie team, include user incentives, higher level user upload and the enforcing of user roles. One such role, called the 'Maker', requires a set of user inputs for the creation of a new experiment or activity, information that would need to be validated and stored by the system.

Further functional processes required by this project include integration with pre-existing infrastructure and applications. This includes the integration of existing activities, physical experiments, and software (or web) based coding standards already in existence. The Integration of these elements, such as the RAL (a mostly physical device) with the UCAS (primarily web based application), can be made possible with the help of a digital medium. Most often in web page creation a digital database is used to hold, store and cross reference information between systems. It is imperative this medium can be accessed and updated quickly and efficiently, this is aided through the use of correct database design. The interface and associated functionality behind it are expected to go through numerous testing and validation phase, which will help gauge its effectiveness, usability and essentially help guide and polish development.

To help fill the need for extended STEM education, as well as, engaging and introducing students to STEM fields, this project aims to create a user interface allowing access to remotely driven experiments that have academic merit. Many aspects of the interface and its function had to be considered design began utilising alternate teaching styles better suited to the nature of the medium whilst becoming a purposeful addition as a teaching tool. To aid in the engagement of potential users it seemed prudent to create digital incentives for the users, in the form of an points-based mechanism, much like those found in many video games, much thought was also given to the user accessibility of the interface in an attempt to make it as visually appealing as possible. This attention to detail and structure gives this interface the basis to build or alter at a later date, adding or removing functions as necessary and possibly opening it up to a larger of community of support in the future. This process of design and subsequent development will be evaluated and validated in regards to its functionality and ease of use, and could utilise user testing results to refine the process. The core aim in this project is the creation of interface that integrates access for remote experimentation, to understand the underlying driving purpose behind this goal research must be conducted in parallel with any physical work being completed.

## 1.4 Research Objectives

Research material was required to establish the current emerging trends in education, user interfacing, and remote technologies; this would help to identify and alleviate any potential problems or required parts in the design and development, and to cement a firm understanding of main purpose and aims, as well as any ramifications. Material was first sought to confirm initial hypothesis concerning the current state of Australian Higher Education, and to gain a better understanding of future trends of employment and structure of Australian workplaces. An important step during research is to establish known correlations associated with these subjects and also to search for and make reference any reliable information which may be contradictory. Due to the nature of the work in the education sector, it seemed prudent to understand the current state of STEM education, especially in regards to the necessity for a certain amount of practical work in the subject fields, as well as its presence in schools. Further comparative study of case studies and closed experiments would build the basis for the argument that such practical work can not only benefit students greatly but is also an essential part of understanding higher level concepts. Research has also delved into the ethical and safety issues present on an application that has the potential to reach everyone on the World Wide Web. Validation of research outcomes will come initially though derived knowledge and constraints, required for the design phase of this project. The validity of these implementations will be tested during the development cycle where theorised requirements will be integrated into the interface. This evaluation will progress later in the project as the interface undergoes user testing and feedback. The research objectives will be considered complete when integrations of researched standards (or derived norms) and the interface are finalised and reflect the overarching purpose of the UCAS.

This project has given rise to the requirement to research in both common and alternative teaching methodologies. In order to suit the teaching style to the demographic it was concluded necessary to gauge the progression of modern education to discover which forms were gaining popularity and illustrating effectiveness and which were now failing to make an impact on students. It was important to pay close attention to any information which may corroborate or contradict these claims to give a fair and unbiased view of students in primary, secondary and tertiary education. The research into education methods also takes a comparative view of both practical and theoretical teaching styles, and is to be evaluated on its effectiveness on students or developing professionals. It was deemed necessary to identify current norms and strategies involved in the creation of a usable and appealing web-based application. With specific importance placed upon functional elements required to drive the main utilities and processes of the UCAS, whilst considering the placement and overall visual appeal of its use. Further research comprised of studies down into the possible positive outcomes of the integration of ‘game-like’ elements, also known as gamification. The research allowed a very distinct definition and categorization of the current major gamification elements which can be used for the purpose of engaging and pleasing users through intrinsic and extrinsic reward systems. Research and study into the hardware and software components that help drive the remote technologies is continuous and ongoing, services and technologies are being released everyday which can be utilised easily to streamline processes and make it even easier to learn and share experiences on huge scale. Sufficient research is important to stay abreast of standards and preferences that are vital to producing the framework needed for good design practice.

## 1.5 Design Objectives

At the core of the UCAS development is the nurturing and encouragement of learning based around STEM subject material. By streamlining currently used simulated and physical experiments created and residing at USQ, into a single remotely accessible interface, users worldwide will have the opportunities to engage actively in learning. This process will also provide users of the systems to challenge themselves and expand higher level critical thinking and hopefully stir interest in a chosen field. The design was required to complete only the basic functions of the interface, that is, to store information on experiments and users and be able to retrieve, change and add to that when required. It was built as a series of interconnected functional blocks that could be tested and viewed separately before forming them together. There was a special considering given for future testing, development and design imperatives passed down by stakeholders, and to that end, it would be built in such a way that many of the added features such as gamification and user upload can be utilised or removed from functionality as required. The structure of the design and coding had to be robust as to allow multi user simultaneous access as well as control the flow of information between the user and the interface.

## 1.6 Conclusions

The outcome of the following study and design methodology is used to facilitate and guide the development of a user interface built to assist in remote education and engage users in self-driven learning. This project will be designed around the potential positive influence it may create in the face of the emergent problem of a lack of academics, coupled with needs for such professionals increasing annually. Research will identify emerging teaching styles utilised and preferred for integration into the web based form of media. In addition this study will provide a foundation of knowledge that underpins both the desired outcome, a remotely accessible interface based upon STEM learning, and the positive consequential effects and responses from users. The following will aim to establish a requirement for such a project to be completed, as well as, methodologies utilised and design parameters necessary to aid in the correct development and deployment of the interface.

# CHAPTER 2 – LITERATURE REVIEW

## 2.1 – Introduction

The following literature review fulfilled a requirement to establish a base of knowledge on key subjects, as well as test initial hypotheses raised in regards to the current state of higher education in Australia, select education methodologies, teaching tools, and the driving need for their reform. The review of current standards in design, interfacing and teaching pedagogy were necessary to aid in modelling design and understanding concepts associated with the user interface being constructed. Research into current trends relating to current education standards, styles and effectiveness of STEM (Science, Technology, Engineering, and Mathematics) teaching was used to highlight the changes in preferred learning style that are being adopted by current students.

To aid in the understanding of the project, it is also necessary to include research pertaining to the current technologies applied and how they can be best utilised to gain the most positive education experience. Investigation was required to ascertain the validity of digital or remote learning through a critique of alternate and current teaching styles utilising a comparison of past studies, and research done on the subject. Furthermore, research into the construction, access and running of a remote laboratory yielded many great constraints and design requirements on the final model, which helped guide development and streamline the coding process. This research also created a necessity within this project to create an application that falls within specific social and educational 'norms' of this research, to remain meaningful in an academic sense, and appeal to certain user groups. The interface functionality and design validation will be derived, in part through the research provided. These research elements combine to support the knowledge of what is both physically required for the project, whilst underpinning the need for such work to continue and expand.

## 2.2 STEM Education

Interests and innovations in STEM subject fields have increased exponentially over the last decade and will continue to expand as more important and convenient technologies are discovered. Highlighted within this review is the need for further student interest to be generated in said fields, according to projections of highly skilled professionals required over the next ten years. Furthermore studies into similarly placed overseas countries aim to confirm and underpin the needs of the future Australian workplace. In addition, to emphasise the dire need this country faces in coming years, current trends in depreciating tertiary education completion numbers in Australian students will be investigated.

Much of the STEM subject matter also has specific educational requirements that need to be adhered to create a positive learning experience. These teaching obligations will be resourced from existing documents and studies on the subject and will aid in outlining the STEM learning environment whilst exploring its appropriateness at the primary and secondary schooling level. The further research found in the proceeding sections will aid in drawing conclusions on the inherent necessity for added interest in STEM field research and study, especially in the next decade.

### 2.2.1 Necessity for STEM Learning

As the world develops and grows it has shown to become more centered on technology, thus with each new technical innovation the complexity of life increases, requiring a more problem focussed and skilled workforce. A recent review of the Australian Higher Education sector noted a declining or static figure of young (aged 25- 34 years) Australians completing tertiary education and was stated in 2008 to be 29% [20]. Projections concerning the needs of such tertiary education professionals, found in the same review, estimate the need for an increase in this number to 40% by the year 2020 to fulfil future positions that will become available. Some specialised fields in STEM study, such as biomedical science, medical engineering and system development have been predicted to rise by up to 50% in the next decade [20]. In addition, the review of higher education stated the need for an improvement in the number of Australians graduating tertiary education. This move would improve Australia’s potential to contribute to and compete with the global research markets in the face of a “looming shortage of Australian academics” [Bradley, D., et all, 2008]. A statement further underpinned by the dropping two places in the Organisation for Economic Co-operation and Developments international comparison of education attainment (see Figure 2.2) [20].

Comparative analysis of trends found in Australian and the United States of America show many similarities in projection analysis, show a much heightened needs for highly skilled workers, in some cases a much larger increase in the same STEM positions mentioned above (up to 64%, see Figure 2.3) [34][35]. And although the graduation rate of The US shows small growth (less than 10% per year), this does not meet the projected requirement, unless intervention occurs there will be a seemingly insurmountable amount of jobs to be filled. In both countries reviews, a request for more involvement of STEM subject matter in primary and secondary education was deemed necessary to bolster numbers of tertiary completions. It was concluded that to help ‘inject’ STEM disciplines into standard pedagogy, alternative teaching methods would have to be utilised. This process, itself, could create potential problems due to the insufficient knowledge of education necessities and qualifications which may be held by some primary and secondary education professionals.

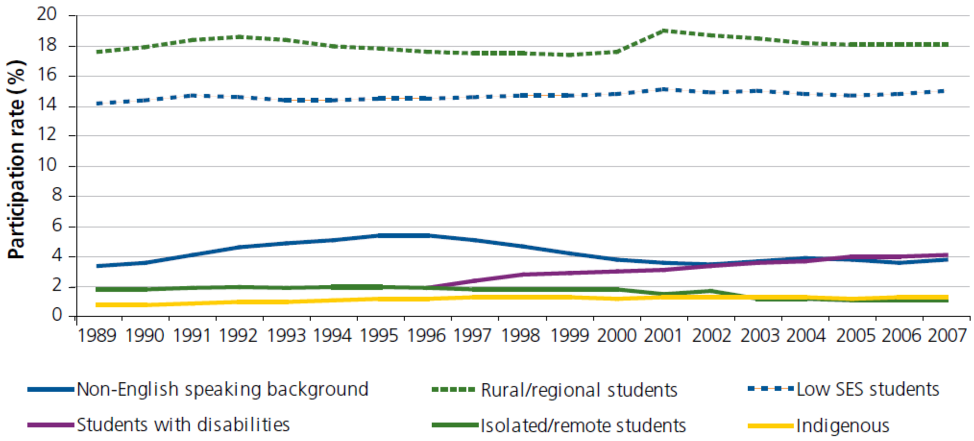
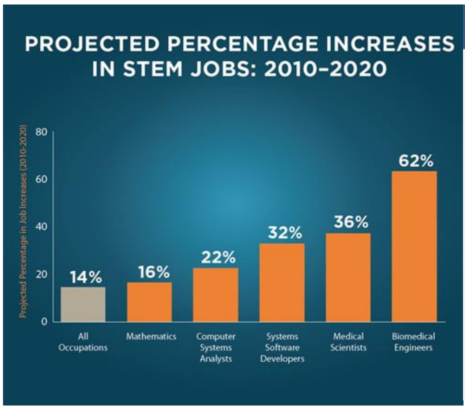



**Figure 2.1** –University participation rates in Australia [20]

| | 1996 | | 2006 | |
|---|---|---|---|---|
| **Age group** | **25-64** | **25-34** | **25-64** | **25-34** |
| Australia | 15 | 16 | 24 | 29 |
| OECD median | 12 | 14 | 19 | 27 |
| OECD - top 6 countries | 19 | 23 | 28 | 34 |
| United Kingdom | 13 | 15 | 22 | 29 |
| United States | 26 | 26 | 35 | 35 |
| Canada[2] | 17 | 20 | 24 | 29 |
| Korea | 19 | 30 | 23 | 33 |
| **Australia - Ranking** | **6** | **7** | **6** | **9** |

**Figure 2.2** – International comparisons of educational attainment [20]



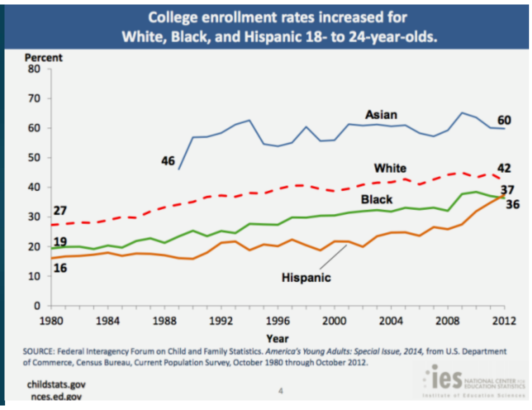




**Figure 2.3** (left) – projected increase in stem learning required for the US [34]
**Figure 2.4** (right) – current trending in college enrolment rates in the US [35]

### 2.2.2 Educational Requirements

The application of teaching methods most often requires a tested and well thought out framework for learning, a set of rules or constraints that are vital to the information being imparted. Teaching STEM centred material requires an applied learning environment [12], the subject matter covered is most often interdisciplinary and focuses on problem solving activities that can be related to real life. This environment helps to develop constructive communication skills as well as the students' abilities to think laterally, work in a team and share information. Outcomes of this process rely heavily on the positive interactions of students and the continued guidance of knowledgeable teaching staff. Through this process the students become engaged by their interest and interactions [14], which is a key to instilling meaningful knowledge of the STEM subjects. Failures in these requirements could lead to incorrect information being relayed to young minds and a change in any participants

## 2.3 Learning Methodologies

Learning methods and practices have come a long way from the lecture based style of traditional learning that relies on the notion of transferring of knowledge from one person to many, with now more and more teachers opting for less traditional methods to engage young minds and enhance their ability to communicate, solve problems and think at a higher level. In recent years a shift in learning preferences has created a requirement for a review of current teaching standards, with more educators finding value in embracing a more active based teaching methodology. Active learning styles can be categorized by the involvement of student in the learning process with the distinct aim of capturing engagement and the stimulation of healthy thought and discussion on the involved subject. In comparison 'passive' teaching methods are more concerned with delivery of information through a one-way channel, that is from educator to student. Furthermore the research contained herein investigates two alternative styles of active learning, namely problem-based and authentic learning, which help to underpin and explore future stated functions of the proposed project interface. These teaching elements combine to aid in conveying higher level thinking activities and STEM learning that engages and entices students to contribute to the completion of tertiary studies.

### 2.3.1 Active Learning

Active Learning is a method of teaching that guides the student into thinking for themselves rather than relies on teaching staff producing full lectures of information, which are considered passive, for each student to attempt to memorize. This method is mainly concerned with prompting the student to access higher level thinking to solve problems and understand concepts [4]. As outlined Bonwell, C. and Eison, J. [5] this can be achieved a number of ways; such as a group discussion which can be analytical or opinionated, an interactive game or a short written exercise, each different ways of stimulating healthy discussion and interest [5]. These mid-lecture moments allow this learning technique to create a sense of purpose and community in the classroom and strengthen bonds between students. Active learning at its core is about short bursts of learning, originally recorded over 3 decades ago Bonwell, C. and Eison, J. [5] observed that nearly half of students lost interest in a lecture after 20 minutes, whilst the whole class seemed unresponsive and passive at 35 minutes, more recent studies have shown this window of interest has actually shrunk in recent years, attributing it to the technological methods of distraction and procrastination now at our fingertips. This difference of learning styles and the associated retention rates generally thought to be applicable are illustrated in Figure 2.5.

In the past the onus of learning has been placed upon the student, but in recent decades it has become increasingly clear that burden of responsibility can be lessened slightly by some minor changes in teaching methodology. Introducing an active element to teaching can be a massive boon to student interest and interactivity; a small discussion or planned activity or experiment has been known to increase information retention. In two recent case studies done by Hake, R. (1998) and Hoellwarth (2011) [9], [8] it was found that students had markedly higher amounts of engagement and retention of information was gauged at an increase of 25% and 38% respectively when compared to more traditional passive methods of teaching. These findings were carried out and made quantifiable by a series of pre and post session tests that evaluated the individual's knowledge and their ability to retain information throughout the lecture. Furthermore both studies confirm that "conceptual understanding through interactive-engagement of students…yields immediate feedback" [9]. While the benefits to students are decidedly clear it is not appropriate for active learning to exist in all subjects, there can be time constraints, as each active learning process requires time to both plan and undertake, which is finite in a traditional timed class [8]. It is not uncommon for students to resist the idea of interactivity in class, as deviation from preconceived standard learning methods and material predisposition may sometimes aid in the failing of active learning [8], even more experienced and older students have shown resistance to new material that contradicts a pre-existing self-perceived notion [27]. Given these empirical results, coupled with the deteriorating number of Australian students attending universities, it is seemingly a practical choice to explore alternate teaching and learning methods that could possibly contribute positively to a student's knowledge, as well as engage their attention and impart interest in the subject material.

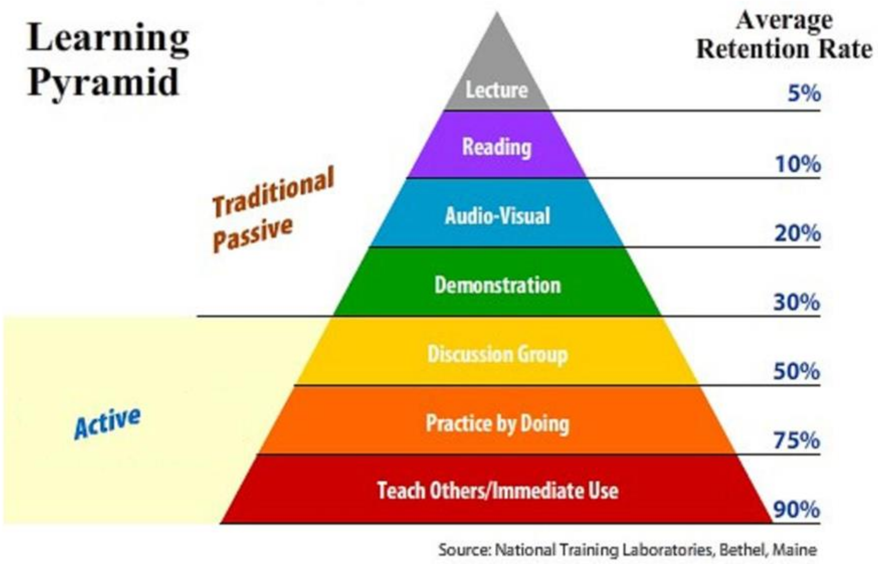



**Figure 2.5** – Average retention rates associated with active vs. passive learning <http://www.survivalandmedical.co.uk/services/training/>

### 2.3.2 Problem Based Learning

Problem-based learning (PBL) is a specific style of active learning, focusing on the students learning through teaching, shown as the most effective style of active learning (Figure 2.5). Ideally PBL consists of small teams of students working towards creating a specific problem which can be solved, usually by classmates, in most cases the accepted or expected solution is already known, or needs to be found out and groups have to reverse engineer an experiment or test where this solution can be reached and thus the knowledge gained. It encourages lateral thinking [9] and self-directed learning whilst improving problem solving skills more readily associated with the real world [10]. It is a physical based learning method first deployed in medical training [10] allowing students to develop personal thinking strategies whilst drawing from retained knowledge. PBL exists primarily to provide a service to students, when investing in subjects such as medicine and engineering it has become the teaching imperative to include problem centric styles of learning, to increase understanding and the use of higher level critical thinking of the students involved.

### 2.3.3 Authentic Learning

Another form of learning utilised within this project is referred to as authentic learning, it can be considered a form of active learning as it is student focused and non-traditional [28], but follows a constructivist approach. Constructivism is a teaching theory that stipulates human interaction; by exchanging ideas, points of view, and meaningful knowledge, students are unknowingly being actively engaged in the learning process [29]. Teaching staff using authentic learning as a tool direct their students to work in groups, often interdisciplinary in nature, to discuss and solve problems more readily associated with the real world [28]. This provides obvious benefits to the students' ability to solve problems, stimulating higher order cognitive processes and instilling effective communication skills, but is also much more effective at equipping students with practical abilities that can be utilised in future careers. There are, however, pre requisites that need to be reached for authentic learning to be a positive experience; firstly all students involved require a fundamental understanding of content (of their given field), due to the necessary exchange of correct information that is essential in this process, also facilitators are required to play an active role in lending focus and direction to the tasks [28]. Failures in the active learning process can come in the form of a lack of activity direction, knowledge or appropriate guidance and moderation, which can cause a breakdown of communication between participants and essentially become meaningless. The success of active learning lies within its ability to stimulate productive thought and interaction, whilst imparting practical and meaningful lessons.

## 2.4 Remote Learning Technologies

Remote learning has become a driving force in education since the inception of the internet has given members of this planet a greater ability to communicate and share information. An integral part of learning, especially in engineering and science based subjects, is a combined study and application of both theoretical and practical knowledge [2]. Through practical experimentation students find a more active way of learning, engaging higher level thinking to solve problems that are relatable to theoretical knowledge and comparable to real world actions. Remote assisted learning helps to bridge the gap for students who live or work remotely; by giving them the opportunity to access experiments from remote locations, it can bolster their theoretical knowledge and give true to life experiences. In this vein the University of Southern Queensland (USQ) has built the Remote Assistance Laboratory (RAL) with the main purpose of providing a quality and meaningful experience for its external students [1]. For remote technologies to work as expected and fulfil purposeful educational goals it is important to understand both concept and design of such a system. This research will help define the physical and software based properties that exist currently in remote technology, as well as outline any constraints or requirements this technology may impose, in regards to both research and physical project outcomes.

### 2.4.1 Design of Remote Laboratories

A remote laboratory usually consists of a series of experiments, being monitored by measurement equipment as well as live video streaming, which allows the students a greater feeling of immersion within the project, as well as familiarise themselves with the equipment readily used. The information regarding these experiments is to be held within a database (series of tables), which resides in a remotely run server, this makes all the information regarding user records, experiment traits, and locations easily accessible. This server, and its constituent held information, is accessed via a remote link secured by the interface, which searches, displays, modifies or creates new data held within the tables [1]. The interface is the only thing the users of remote laboratories will often see, the commands entered to engage experiments are interpreted by the back-end applications and transmitted to the experiment, with the user receiving values or visual indications in return. Potential users can connect through the interface with a personal computer and internet connection and gain access to the complete interface once they have registered and been given the necessary privileges. The existing elements of physical and software based design concerning the desired project outcome will have to be designed in a way that makes the integration of this pre-existing infrastructure simple to develop and maintain. Validation of remote laboratory design and integration will be predominantly to do with the speed of communications between the apparatus and the student, as well as the functional traits and potential improvements of the development.

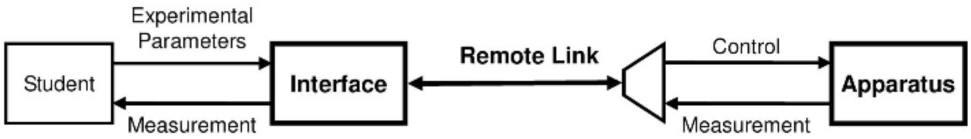



**Figure 2.6-** Basic overview of a remote access laboratory [15]

The idea of a remotely driven experiment was conceived in the early 1990s. Since then, numerous papers have been written and published on the pedagogy and associated effectiveness of remote learning as a teaching tool, with new advancements in technology remote learning has never been more popular, illustrated by the majority of the western population now owning personal computers, not to mention a myriad of other devices as well as the improvements in live streaming and scientific observation equipment. Universities, all over the world, are being driven to adapt to these new technological advancements and innovations to be more accommodating to their external students and take a larger role in shaping their critical thinking and real life relatable skills [14]. This modernization of teaching and teaching tools is now becoming a necessity in many universities, with Kist, A. and Basnet, B. of USQ, finding “In the Faculty of Engineering and Surveying 76% of the students are not located on campus and study via distance education” [18].

### 2.4.2 Remote Laboratories as a Teaching tool

The arguments that exist presently are not so much for or against remote learning, they are focussed on its appropriateness as a learning tool and are comparing it to the more traditional ‘hands-on’ experiments in an effort improve current drawbacks in the process. Euan, D. (2005) wrote that students undertaking learning through a remote laboratory don’t experience the haptic feedback of a physical experiment, they also run the risk of feeling disengaged from the system either due to lack of motivation, mediation or understanding of the topic [17], [18]. These risks are further underpinned by Shyamala, C. [16] and in statistical driven testing, carried out and documented in both papers, of both on-site and remote students found a variable difference in their learning outcomes, with the on campus students being able to seemingly process data, accuracy and assumptions at slightly higher levels than those located off campus. Corter, J. [19] found relatable but differing results in a comparative study between remote and hand-on laboratories, but expanded the discussion by postulating a students’ mindset, mood and ability to intake information through different means is at the core of the issue, stating a students’ preference to their form of learning is based on their visual, auditory, read/write, and kinaesthetic inclinations, “a preference for aural material was correlated with a feeling of immersion in the remote lab” [19]. Further case studies have yielded similar results, finding certain remote access laboratories that actively engage students (through motivational means) while delivering all required learning objectives of the subject [18]. Conclusions were drawn in regards to the quality of the experiment, as well as the interface it is built upon, the interface design over all else, was deemed as having a greater impact on a student’s enjoyment and understanding of a task than the actual functionality it was built upon.

The remote labs main function is to allow students to undertake simulated and real time physical experiments from a remote location. For this to be a positive influence certain requirements need to be met [5], [14]. In an education sense it is required to engage students to participate and find meaningful development through completing experiments that fall within a certain curriculum [16]. The technology must be secure, have the ability to differentiate users, and it would be beneficial if it came at a very low cost to the community, thus increasing accessibility and widening the potential user base. There are also requirements of the user; they must have the minimal abilities to access and use the interface, as well as the relevant background information on the subject that will allow them to complete the learning activity and gain a meaningful experience. Evaluation of this project as a teaching aid will be reviewed based upon its functionality, similarities to standard teaching tools and user feedback.

## 2.5 Gamification

The introduction of reward based user gratifications, especially into solo or self-driven learning activities is seemingly a viable and easy feature to implement. Research and testing must be completed however to evaluate possible negative and positive consequences associated with select gamification elements and goals. Gamification is defined as the process of adding game-like elements or mechanics to an activity to increase user interaction [7]. It is intended to motivate users to complete certain tasks or improve system usability through the use of a gratification system aimed at creating pleasant experiences by stimulating emotional and behavioural responses [21], [22]. In the context of this project the gamification elements being used are primarily to engage the motivation of self-driven learning and will allow the user to be rewarded points, track their progress, and grow into new roles within the user community.

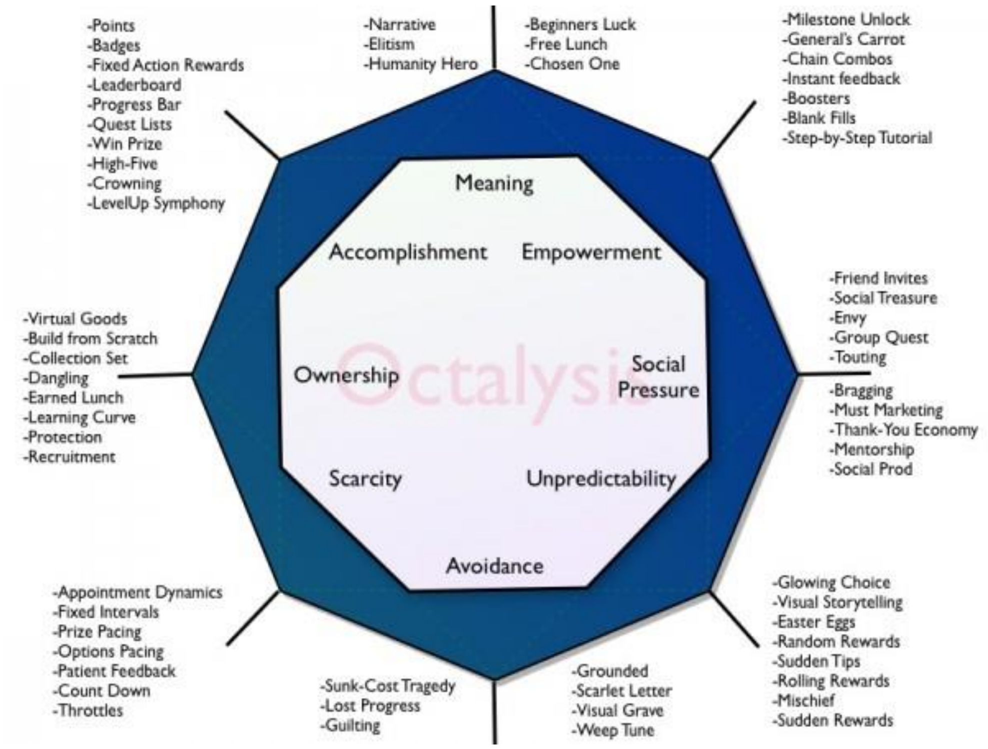



**Figure 2.7** – Example of gamification framework with descriptions <http://www.yukaichou.com>

The term gamification was first used to describe the ‘game-full’ nature of non-game experiences in 2004. As such arguments currently exist about the term that is of a rhetorical nature. These arguments surround the term being a misrepresentation of gaming and are held by many gaming industry professionals and advocates. The claims are illustrative of the process, currently undertaken for gamification, which includes taking small pieces of a whole experience (a video game) and trying to build an experience around it [23]. Counter arguments exist for the use of the process as a teaching tool; these describe gamification as a simple mechanic employed to aid in solving problems [23]. Other words have been suggested to aid in the description of the term, namely “gamefullness” and “pointsification”, and although these terms seem to give a better description to the process they have not replaced the term in common use. Until a new terminology is agreed upon by the greater research and professional community, Gamification will continue to be seen as a term not satisfactorily derived.

Gamification elements associated with this project have been discussed and stipulated at an earlier date. The elements chosen to be included within the interface were points (in the form of experience), badges (also called achievements or awards), as well as user progression and some form of user communication. It can be seen from Figure 2.7 the majority of these elements fall within the accomplishment or empowerment driven aspect of the above framework of gamification. Possible inclusions for design factors are complementary to these elements and may come in the form of a progress bar (to gauge user growth), level progression (which may engage long term users) or quest based lists.

### 2.5.1 Effect of Gamification

The effect of gamification elements can be quantified to a certain extent by investigating the emotional, behavioural, and psychological responses users have towards the material. Although some of these responses will be dependent upon the person (in terms of social and psychological factors) [23], it is the only process that can be followed to produce meaningful insights into the outcome of gamified material. The human emotional response can be characterised by a change in a individuals feelings these tend to promote changes in physiology as well (crying, laughing etc.) and can drive a person in certain circumstances to trigger a behavioural response. A behavioural response is quite similar to an emotional response but more akin to a knee jerk reaction, such as a startle from a fright. A common human response, psychological responses arise within the mind and focus on areas such as memory, attitude, motivation, and enjoyment [24]. Users (or players) motivations are said to fall into two groups, intrinsic, or those created internally, or extrinsic which rely on external stimuli. Intrinsic characteristics of a player may include his/her willingness to help others, express themselves creatively, and non-competitive social aspects of the process; whilst extrinsic motivations include the receiving the points or awards, competitive social activities and team based activities that are goal orientated [21]. At the introduction of a gamification element to system a user of the system becomes a ‘player’ and the immersion of the process is considered the most important factor in contributing to the motivations and overall effectiveness of gamification, in terms of a teaching delivery method.

A recent and in-depth study into the possible effects of the addition of gaming elements to online teaching was presented by Herbert, B., Charles, D. and Moore, A. This study conducted research to examine the benefits (if any) gamified elements could have to a tertiary students ability to retain knowledge and be entertained. Applicants of the study were initially asked to answer a short psychological based survey to place them into one of 14 different classes. These classes were derived based upon known psychological guidelines to do with personality and sorted students relating to the amount of intrinsic or extrinsic motivation sought by the user. Notable amongst these initial research results is the prominence of the two most popular classes; the ‘self-seeker’ and the ‘socializer’, which when combined totalled nearly half of all students in the study (see Figure 2.8). These two classes illustrate the most widely seen personality traits especially in regards to gaming, that is the extrinsic seeking user who derives satisfaction from completion, awards, and bragging rights and the intrinsically motivated social user who is happiest when communicating, helping and co-operating. The study gauged aspects such as retention rates and overall mark movements using a series of pre and post-use tests (in addition to the initial psychological survey), which were then compared with the students marks and marking averages until the point the study began. It can be seen from Figure 2.9 that the noticeable increase in overall marks occurred in 13 of the 14 classes.

| | Philanthropist | Achiever | Socializer | Free Spirit | Self-Seeker | Consumer | Networker | Exploiter |
|---|---|---|---|---|---|---|---|---|
| **No. Learners** | 14 | 6 | 23 | 7 | 24 | 12 | 20 | 10 |
| **No. Responses >= 90%** | 3 | 2 | 5 | 4 | 7 | 2 | 5 | 4 |
| **No. Responses >= 80%** | 4 | 7 | 10 | 6 | 9 | 13 | 9 | 7 |
| **No. Responses >= 70%** | 10 | 13 | 10 | 10 | 22 | 18 | 14 | 7 |
| **No. Responses >= 60%** | 15 | 19 | 23 | 10 | 17 | 19 | 26 | 17 |
| **No. Responses >= 50%** | 23 | 25 | 25 | 24 | 16 | 16 | 22 | 19 |
| **No. Responses < 50%** | 35 | 23 | 16 | 37 | 18 | 22 | 14 | 37 |
| **Mean Response** | 55.8 | 58.3 | 64.2 | 53.0 | 56.7 | 56.2 | 61.9 | 55.5 |
| **Standard Deviation** | 18.9 | 14.7 | 16.2 | 15.6 | 20.8 | 17.3 | 18.8 | 21.2 |

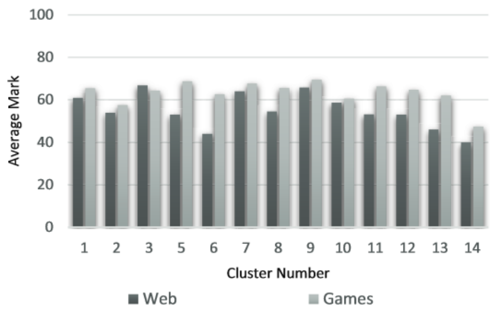



**Figure 2.8** (left) – showing distribution of users in study, sorting by character traits [21]
**Figure 2.9** (right) – comparison average mark when compared to standard delivery [21]

The aforementioned study into gamification illustrated some positive potential benefits of its use, though, it is to be remembered that the majority of gamification elements are subjective and as such not every user will enjoy the same element, or if they do it may be for completely different reasons [7]. Certain pitfalls exist surrounding the process and without careful selection and design of gamified material, there lies a potential for negative effects on the user. Repetition of gratifying elements (such as a musical fanfare for example) will lose impact and become may become annoying to a user if used many times within a short period of time, which will relate a feeling of boredom and repetition to the task [24]. Research concerned with subject calls for a strict limitation of gratifying elements, and the introduction of staged or progressive achievements, recommended to mitigate the potential for gamifications to lose their impact, and thus their meaning. Used for the wrong purposes, gamification as a process and term has been sullied, businesses hoping to exploit certain traits in users or potential customers have used web-based gamification incentives for their own devices. Some have been accused of trying to sell game-based incentives, which are intrinsically worthless, to customers in return for real money or customer loyalty, starting the argument gamification can be used for persuasion and exploitation [22]. This point is moot in relation to the majority of academics projects or endeavours as they are not aimed at profiting and are run for entirely academic purposes.

### 2.5.2 Addition of Gamification Elements

Adding elements of gamification requires careful analysis of the medium and content to create a positive experience for the users. By using researched methodologies on the selection of game elements, the risk of over (or under) gamification [22] of a system can be reduced, this helps make sure the requisite information attempting to be conveyed is not obstructed or too minimal and unappealing. Yohannis, A. described the nature of game to be characteristic to nine elements; player, environment, rule, challenge, interaction, goal, emotional experience, quantifiable outcomes and negotiable consequences [21], [24]. By aiming for a suitable number of these elements, making sure not to outweigh the functional and/or educational characteristic components of the system, an effective method for self-directed learning can be created [22], [25].

A more simplified view of gamification principles was set out by Harami, J. in a recent review of gamification related to peer reviewed literature, gamification was described by its possible outcomes, namely; motivational affording of the user drives psychological and emotional outcomes [24]. Another commonly encountered annotation found across numerous literature findings is the demographic direction; the users age, environment, and ability to receive meaningful information from different forms of media [23], [26] can have an impact on their ability to be engaged and learn, thus systems need to be tailored to reach their distinct or indistinct target audience [25]. In the principles of gamification set out by Harami, J. there is stipulation that gamification material should not exceed or overshadow the core material, and that a good mix of elements is required to produce the correct outcomes. The key principle in nearly all arguments is the immersion of the player into a functionally built and gamified system; by motivating a form of self-directed learning a productive and profound learning environment can be created.

As mentioned earlier, gamification is a generally new term, and as such must be treated as somewhat hypothetical requiring of directed user testing, until extensive research is complete. Imperative to this process is the gauging user responses relating to gamified additions to pre-existing and recorded material. By doing this the effectiveness of elements can be validated or refined as required. It can be seen from of the research in this field that users seem to favour socialising and achieving whilst engaging in gaming. Due to this it is seemingly beneficial to cater to these markets to some extent. Further recommendations have been derived based on the addition of gamification elements, in that the elements themselves should never be used as the ‘core’ experience. Outlined also were the negative effects which may occur from over saturation of gaming elements, which had the possibility to overshadow any other core elements. Conclusions on the use of gamification can be drawn in regards to its seemingly positive effect as a teaching aid and motivating tool, though nearly all research materials outline the requirement for further research, testing and validation to occur within the field.

## 2.6 Interface Design

Interfacing fundamentals mainly refer to interface design as a combination of aesthetical and functional validation and is considered to be one of the main determining factor in user satisfaction [31]. Aesthetics refers to an individual’s perception of something and whether they find it to be visually satisfying. It is concerned mainly with the areas of shape, composition as well as the physical properties they possess. Aesthetics does not exist as a shared experience, it is subjective (meaning different for each person), and thusly when issues of aesthetics arise certain care must be taken to ensure consideration is given to individual thought process [33]. The main elements outlined across research and case studies to do with aesthetic appeasement are the strategic choice of colour, text, typography and the composition these elements form [32], along with a requirement to retain an amount of consistency through all parts of the interface. Each element chosen (button, colour, text) and displayed to the user must be purposeful and possess a meaningful quality (action, information, encouragement, suggestion), which should fall in line with the object itself. This designing of elements must be purposeful, with full appreciation of the target demographic or culture. [31] [32]

The functionality of an interface refers more to the integration of elements and ease of use as opposed to the functions themselves. In terms of functionality an interface should provide functional components that are driven to a certain purpose but also hold meaning to the user. Implying the integration of function based elements, created through code development, are required to suit the physical design as well [32]. An example of this could include the addition of fading elements in and out to create smoother transitions; this would have to be conveyed to the developing team and would require the collaboration of the design and development stages to form a working and visually pleasing outcome. The majority of functionality in the interface should not be visible, users should not be alerted to any background operations unless they are required to be. System processes that may take time (more than a few seconds) need to be communicated with the user to avoid frustration, thereby changing the emotional and behaviour responses the user may have towards the interface in the future. At the core of all these elements is simplicity, a user interface should not be visually crowded and the selection progression for one page to the desired next should be easy to understand and control. [32]

Research into interface evaluation has been thorough yet varied, due to the subjective and ever changing nature of aesthetics and functionality. Recent studies into the subject show comparative analysis of varied user interfaces. Qanber, M., et all, in 2012 used an international standard for the evaluation of software quality, the ISO 25010 [31]. This method compared a number of defined characteristics required in an application and evaluates through a series of tests relating to the comparative value, taking into account very common aspects of human bias that can affect perception [31]. This evaluation method relies more on mathematical means to derive a percentage of compliance with the standard document. Standards like the ISO 25010 exist as a formal evaluation method based around the strict principles of design; the information gained from such a venture will be narrow but the quality and quantity of the results are straight forward and easy to understand and implement.

An alternate case study [33] completed in 2010 by Kalsom, N., et all, details a process whereby an interface was evaluated on the basis of human cognition. Cognitive abilities are those of or relating to mental processors such as memory, reasoning and perception. The study began by evaluating its users in terms of certain human cognitive characteristic and physical means of perception and judgement (ie. how they complete a task). This testing took the form of user survey, observation and data collection and through this process the research laid out a means to create a simplified mental model of each user. A mental model is essentially a description of an individuals thought process, which affects perceptions and intuitions that create physical responses. Modelling is then continued through observation of user in standard operation to help create a human information process model which shares traits with the mental model. These two models are then compared to a predesignated set of interface characteristics to evaluate the validity of the interface in regards to human cognition. By allowing subjective elements into the testing and research processes more purposeful information concerning the design and development phases obtained, but always comes with the risk the data may be skewed towards popular opinion, culture, mood and environment.

## 2.7 Conclusion

From the above research it can be concluded that the numbers of tertiary educated professionals has been stagnating over the past decade, whilst the need for such individuals has risen and looks plausible to continue on its trends in coming years. The learning and teaching methodologies explored focuses on active learning, using techniques developed exclusively to include student interaction and attention on large and small scales. Two important forms of active learning are also included in the focus of this literature review, authentic and problem-based learning, which form the basis of higher level construction based features to be implemented into the interface in future developments. This dissertation also aims to draw conclusions about the design and functionality of the interface based around its general level of appeal to users. This is done through research and selection of elements that work together to increase user interest without overshadowing the quality of the subject material. The research will be pivotal in the derivation of constraints, requirements and guidelines when defining the methodology this project will be based around, as well imperative in the evaluation and validation phases of the interface. These elements of form, function and design are combined to aid in the outline for development of methodologies that will spur the continual improvements of the expected outcomes, principally centred on the release of the UCAS, a web based interface to utilise and share current remotely accessible experiments.

# CHAPTER 3 – METHODOLOGY

## 3.1 Introduction

The information collected in the previous chapter drives the influence of the user interface, with the help of real world practices and physical based work the methodology shapes the design and development practices and outlines key milestones. This chapter will outline the tools and processes that will be utilised during this project creation as well as any technical constraints or research based guidelines that may be applicable. This information will also help guide the creation of system topology documents, which can aid in the understanding of the system, and the required factors for its integration. The purpose of the methodology is to justify the design choices being made and outline the constraints of the project set down by the research.

## 3.2 Research outcomes

The research documented in the previous chapter aided in defining a set of constraints and requirements that helped to shape the design and development of the User Centered Activity System. It also helped in highlighting the requirement for more focus to be placed upon future graduates of STEM subjects, which can be concluded to be in the best interest of both Universities and Australia as a leading nation in research. Initial outcomes included a definition of the learning methodologies most closely related to this process being employed, namely Active learning, which came with its own recommendations associated with time and knowledge constraints, requiring activities to run within a certain time frame and for appropriate guidance to be given during this time. Extended research into active learning outlined the potential use of two derivative forms of the methodology, problem-based and authentic learning which are focussed on contributing to a student's ability to conceive of higher level learning processes and critical thinking by encouraging active participation in the activity and experiment creation process, which would in time, create a greater pool of knowledge for others to draw from. This research is due to the design of a key element to be implemented with this project, the 'Maker' and 'Builder' processes, which aim to provide Authentic and Problem-Based Learning in the form of a homemade physical experiment or goal-based activity.

Research driven design factors continued to be formed over the course of the literature review, and were based primarily upon being intrinsically and aesthetically pleasing to the user, this included ease of navigation of the interface, potential gratifying elements, and the overall ‘look and feel’ of its use, and were based upon predetermined and tested guidelines of user-interfacing. Elements that would help in transforming this interface into an enjoyable experience were also studied and considered in turn to maximise engagement without overshadowing required learning checkpoints and material with academic merit. During research and consolidation with the RALfie team, three potential elements of gamification were chosen to be included, these were the awarding of achievements or badges, the gaining of user experience or points, both of which would lead to the process of role progression, allowing users to become architects of their own learning activities. As outlined in the previous chapter, this selection was done with care and the full knowledge of the potential adverse ramifications of inappropriate use of gamified material, which is in regards to the potential negative, bias or fleeting responses from the user.

The literature review contained within Chapter 3 also documents current processes, structures and standards that are already in place, this research illustrates the need for some feature of the UCAS to be built around pre-existing infrastructure. This is most evident in the main purpose of the interface creation, that is, serving currently active and underused remote experiments that are part of the USQ’s Remote Access Laboratory, whilst retaining the flexibility to add further experiments hosted both on campus and from the personal computers of home users. The investigation undertaken in this subject field yielded positive and usable information on remote technologies and provided a basis for system topologies and work flow diagrams necessary to facilitate the and design and backend functionality of the UCAS. These factors helped establish a solid method of communication between the software driven interface and the mostly hardware based experiments in the form of a relational database, accessed and updated constantly to create a dynamic means of tracking each user, activity and experiment. These components followed the structures and standards of modern web design which benefited from the use of a flexible means of development and deployment suited to the task.

## 3.3 Development Modelling

Whilst overviewing the developmental styles and constraints of the project, in regards to time and resources, it became apparent consideration into a developmental methodology and plan would be of benefit. This development model would carry the project from the initial requirement specification through the design and development phases to final testing and feedback. The model in question would also have to meet certain levels of flexibility, allowing the functions that comprise the interface to be rigorously tested, designed, and developed all within a fixed period of time. This flexibility in the process will also allow for easier gauging of the overall development progress, and motivates direction interaction and feedback from stakeholders. Comparative analysis of developmental models, supported by suggestions made by the supervising lecturer, Dr. Alexander Kist, resulted in the AGILE methodology being selected as the most prolific and fitting model.

### 3.3.1 AGILE Methodology

The Agile process is essentially a set of practices that utilises iterative and incremental methods to produce a quality product whilst still having the flexibility to change design aspects as the project progresses. Using this development model divides the project into functional blocks, which combine to form the finished product; these blocks are worked on in turn taken from design, through development as well as testing, before being shown to the major stakeholders for review. The benefit of this process is the ability to adapt to change and produce work much more in line with the requirements due to the fact that the development process is occurring at the same time the testing feedback can be sought, all requirements as outlined by the preceding research and suggestions by the RALfie team. The agile method can be repeated as many times as necessary to the reach the desired level of consensus, and suits this projects overall length, purpose and required process and functionality whilst the modular nature of the development under this model facilitates a wider range of flexibility and versatility in the final product.

In comparison, the waterfall developmental model (shown below right) is focused mainly on gathering requirements at the beginning of the project, whilst producing documentation during design before testing and releasing the product towards the end of the project timeline.  Whilst the AGILE model (below left) prefers adaptability above all else, allowing the requirements of each functional block of the project to have its requirements continually revised and corrected before progressing those changes through the rest of the processes.

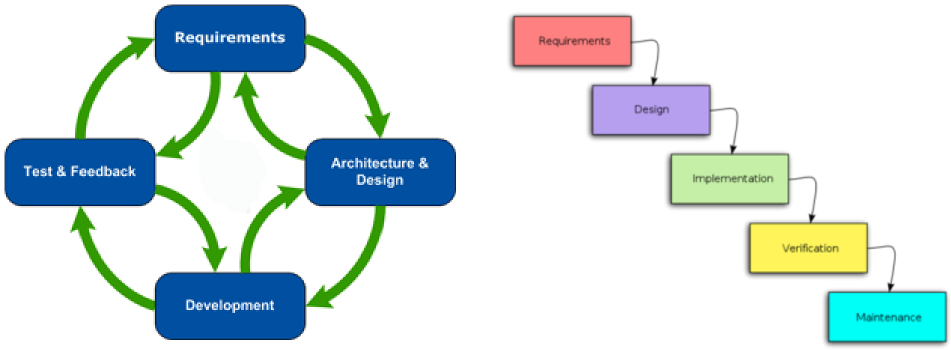



**Figure 3.1 & 3.2 -** Basic developmental models illustrating Agile and Waterfall methodologies
<http://www.myglobalit.com>

## 3.4 System Topology

Topology refers to the arrangement of components that communicate via physical and logical means to form a collaborative system that holds purpose. Creating system topologies helps to map data and work flow and help to characterise the nature and functionality of the system. Due to the requirements of this project to be fully documented for the prosperity of any future stakeholders or developers and to outline the relational values between all components of the UCAS, it was deemed important to document all forms of network topology.

The topology of this system does not solely include the software elements of the UCAS and the hardware elements of RAL; an intermediary element needed to be included that could retain information pertaining to both systems and allow a smoother and more reliable integrations. This medium came in the form of a set of relational tables in a database, hosted online. Through constant updates made by both end systems (UCAS and RAL) a dynamic bond can be formed that allows seamless integration from the users perspective. The integration of a planned relational database aids in allowing the retention and ability to cross reference information between the two systems and can allow for easier expansion of future functions and processes within the system.

### 3.4.1 System Design

Figure 3.3 (below) illustrates the general interaction that will occur between the user and the system, note the isolated responses between the interface and the user, this illustrates a distinct separation between the user and any potential back ground information and processes. After the user connects physically to a gateway and accesses the interface, the interface queries a relational database for information regarding a certain experiment, it is then either modified or displayed to the user through the means of the interface. Once connection to the experiment can be made the graphical interface can relay messages of input and response, whilst transmitting and receiving meaningful data from the experiment.

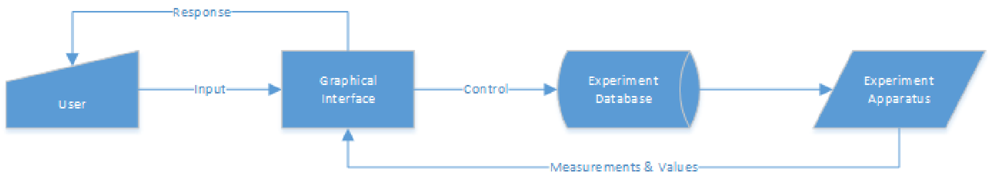



**Figure 3.3** – Workflow diagram of basic user interaction of a physical experiment

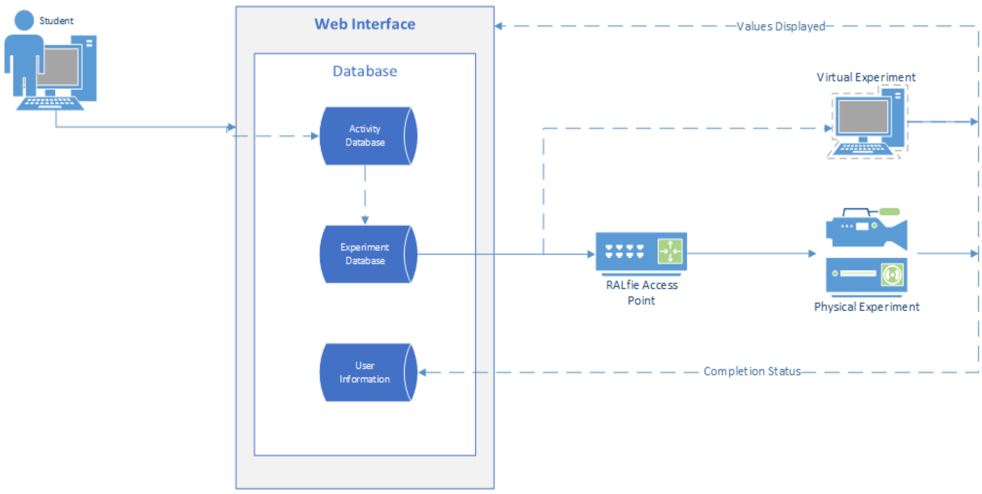



**Figure 3.4 -** Basic illustration of the UCAS System topology

Figure 3.4 (above) is a more expanded illustration of the system topology showing potential logical connections with dotted lines. It clearly shows the basic background functions that need to occur to access a physical or virtual experiment from the UCAS, the database system being used is that of a relational one, this keeps each database relatable to one another helping provide informational integrity while being able to connect and cross-check information by utilising independent identification information regarding each experiment or activity. One table in this database holds the information on the location and accessibility of experiments, once accessed the experiment will begin and information regarding the direction and goal of the experiment is shown, along with any supplementary input from the experiment, such as measurements, video or audio feeds. The activity is completed in real time and the user results are fed back to the interface as well as saved with the user's personal information. At any point the user can also decide to access help files, either via collaborative means or through the experiment itself, this is shown as an intended workflow diagram in Figure A.1 (Appendix A).

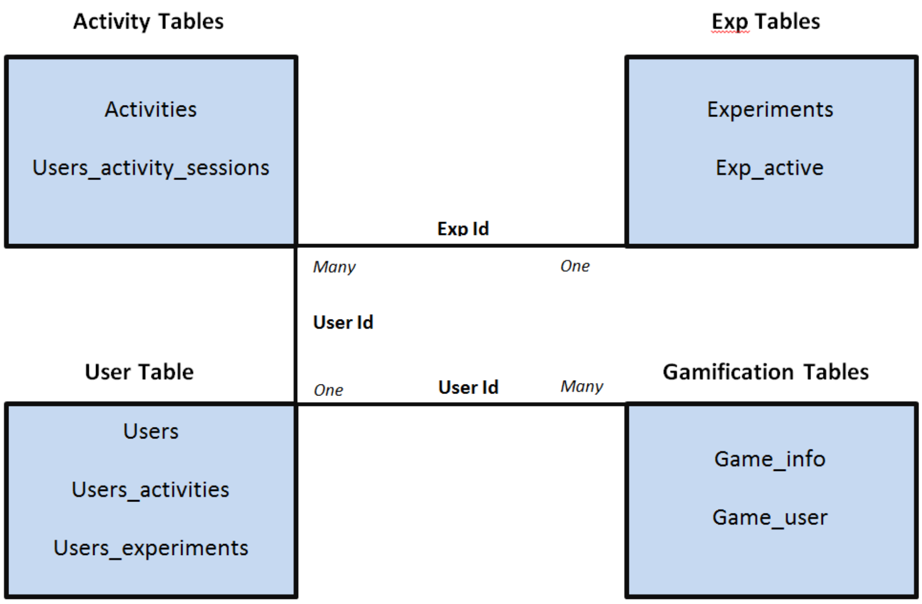



**Figure 3.5** – Basic overview of relational database

### 3.4.2 Future System Topology Integrations

By developing this interface, and its constituent relational database, within a well-structured topology, it was easy to create allowances for future elements and functions that existed outside of the ability of this project and the strict time constraints. These elements included in the structure were those pertaining to the constructivist processes; these processes allowed users to become part of the learning experience by encouraging user input. The processes are currently known as the 'Builder' process, where users are invited to create their own learning activity, either based on a current existing physical experiment, pure research, or one of their own. A second level building process also has a base within the UCAS, called the 'Maker' system, users fulfilling the correct requirements to access this role are, with the help of the RALfie team, able to construct and host, real life physical experiments from their home networks, a process that has the potential to allow massive growth in the community. The foundations of these functions, including relational tables, roles and interface web pages, can be found within the UCAS development repository and associated database, consult Appendix B for future intended workflows of these processes.

## 3.5 Project Architecture

The architecture of this project was guided by known values of system topology, as well as, researched information regarding STEM learning, coding standards and user-interfacing. The inherent purpose of the UCAS is to provide a smooth process by which users can access experiments and activities that are enjoyable and contain academic merit. To accomplish this, a number of coding languages needed to be utilised to get the full functionality required while allowing the code itself to remain robust and readable. This project was required to incorporate the coding practices of HTML5 (Hyper Text Mark-up Language version 5), PHP (Hypertext Processor) and JavaScript. These languages each have a specific purpose in web design and can be used within the same working document; HTML forms the basis of the web document using a series of tags that can be understood and evaluated by web browsing software and translated into visual and functional components making up a web page. PHP is a scripting language that can be easily mixed into an existing HTML document but is compiled and run on the server side (as opposed to the browser side) which allows PHP to help create custom responses for each user, as well as produce background functionality such as accessing a database. JavaScript can also be included in HTML based documents, and forms the basis of any dynamic element existing on each page, unlike other languages that are compiled once; JavaScript has the flexibility for functions to be completed in time with user commands allowing new information to be introduced into the interface when it becomes available.

```html
<!-- Latest compiled and minified CSS -->
<link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.4/css/bootstrap.min.css">
<!-- Optional theme -->
<link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.4/css/bootstrap-theme.min.css">
<!-- jQuery (necessary for Bootstrap's JavaScript plugins) -->
<script src="https://ajax.googleapis.com/ajax/libs/jquery/2.1.3/jquery.min.js"></script>
<!-- Latest compiled and minified JavaScript -->
<script src="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.4/js/bootstrap.min.js"></script>

<link rel="stylesheet" href="ralfie_u.css">
```

**Figure 3.6** – Integrating the extended libraries Bootstrap and jQuery

Additional developer resources were utilised to help in the construction of this web based interface, namely Bootstrap and jQuery. Bootstrap is a library of pre-generated content, which is mainly concerned with keeping the overall system interesting (through its use of buttons, badges and other related content) and responsive, that is be able to be read and compiled correctly by any web browser. This functionality in Bootstrap allows web pages to be accessed from any personal computer or device capable of accessing the internet, and with recent innovations in mobile technology this type of immersion has never been more necessary. Used for simplifying scripting in HTML, jQuery is a free JavaScript library that eases the creation of animations, events and navigation procedures within a web document. Both libraries can be accessed either from hosting locally or through external sources.

### 3.5.1 Design Imperatives

Whilst in the research and planning stages of this project, it became apparent that certain design imperatives would have to be met to make the project a success; these objectives would also include the integration and beneficial use of pre-existing software components. It was decided in early planning of the UCAS that authentication of users would need to occur to provide security, accountability and a sense of identity to the interface. Google Plus authentication was chosen due to its free availability, the ease of use and the ability to intermesh with the USQ email accounts currently in use, this form of authentication would also help keep track of information on users and activities with ease, two important features of the UCAS.

The main requirement at play within the project architecture was the ability of the interface to display a current list of online learning activities available for the user. Detailed further in Chapter 4.3, the UCAS completes this task by sourcing from and related tables of activity and experiment information, refined and filtered by the availability and access requirements. During the design phase of this project considerations must be made in regards to the physical and software components already in use. These components will be researched to evaluate their use and operation and to suit any functional components or design elements that are required to be created. This is principally in regards to the communication of the two systems (hardware based RAL and the software based UCAS) to ensure fast, secure and safe exchanges are being made.

### 3.5.2 Gamification Imperatives

Mentioned in previous chapters, user response to gamified material is subjective, through careful design and the discrete application of gratifying elements a user can become immersed in a learning activity, with purposeful goals, information and awards with little realisation and a very minimal chance of negative impact. These elements will be stored in database tables associated with their descriptive values, methods of achievement, as well as a method to store records of gained awards for each user. To counter the trend of gamified elements becoming less impactful with repetition, progressive user goals were implemented, namely the idea user progression through roles or 'levels', which provides the user with both short term and long term goals within the UCAS. These user progressions are achieved through a series of instantaneous gratifications, whether it be earning experience points in STEM subject fields or awards based on academic achievement within the UCAS, it all adds to the progression of the user, both inside the system and in the real world.

### 3.5.3 Applications Utilised

Numerous applications were utilised during the design, development and testing phases of this project, these tools were used to create visual and functional elements of the UCAS and the supporting systems.

**Netbeans** An integrated development environment (IDE) which provides an interface that allows user to edit, compile, test and run code in languages such as Java, PHP and HTML5. It consists of a number of tools, namely a code editor, debugger and both a compiler and interpreter, applications which allow users to convert their code into another form and to execute it.

| | |
|---|---|
| **MySQL** | An open-source relational database management system, also known as an RDBMS |
| **PHPMyAdmin** | An open source tool which interfaces with a relational database management system to give the user a graphical view of administration with the ability to make changes to the scheme, without relying on SQL commands (though you still can use them). It essentially interprets the relational database scheme into a visual interface, allowing quicker and more concise creating of tables, relationships and user rights. |
| **Apache** | A webserver application that essentially allows users to create a local website on their personal network, allowing them to serve web pages, it supports popular languages such as PHP, HTML and Python. Typically a webserver application processes requests via Hypertext Transfer Protocol (HTTP) much like any standard webpage served by a host on the World Wide Web would. |
| **Git** | A form of distributed version software which allows many members of a group to access online project information simultaneously. Git focuses on speed and data integrity and supports work in the majority distributed workflows. |
| **Repository** | A storage location with all current and previously held information, in this projects case the repository is held online and aids in the storing and maintaining of the project documents. |
| **Trac** | A Git application, which allows users to keep track of recent submissions, changes and bugs, tickets can be raised by any member of the group and stand as milestones in the completion of the project. |

## 3.6 Conclusion

The methodology has set down numerous requirements and constraints derived from theory surrounding the design and development of the user interface known as the UCAS. From a research perspective, the methodology has captured the validity of possible integrations between active learning, STEM education and an interactive online environment. From this conclusions can be drawn as to their effective combination and use in the development of the UCAS. Validation of these methods will also need to be done to ensure the theorised outcomes are met, centered on the ability of the UCAS, and similar projects, to fall within specific teaching guidelines. In terms of physical creation of the interface, the prior research has aided in the clear definition of UCAS aims, mainly the creation of an interface framework that would allow remote access to STEM experiments, with the flexibility to be built upon or refined as required.

# CHAPTER 4 – DESIGN AND ANALYSIS

## 4.1 Introduction

The aim of this chapter is to detail the essential design factors, constraints and developmental pathways that guided the construction of the UCAS and critically analyse its intended use and functionality. This will include dissection methods of coding and functionality to illustrate the purpose and context of technical elements within the system. The methods of data acquisition and storage will be detailed in regards to their ability to support and integrate two functionally different systems. Of importance within design analysis, the potential consequential effects of this application will be also be detailed and mitigating factors will be discussed. Analysis of this project will occur based on comparisons to standards, derived methodologies, and overall outcome achievement.

## 4.2 Project Outcomes

The desired outcome of the User Centred Activity System (UCAS) is to provide an interface where users can access STEM based learning material in the form of remote experiments and activities. This allows users to engage in an active and self-driven learning experience assisted by design implementations that appeal to the user, through gratifying elements and purposeful goals and achievements. Development plans include engaging the users help to build upon the existing material with homemade physical experiments as well as related activities and information. It is the hope of USQ's Remote Access Laboratory that this interface will provide an easy method for users to share these projects and through this process gain a higher level of understanding whilst adding to the educational base for other users to learn from. Project outcomes will describe the project in terms of its achievable results, outlined in Chapter 1, and give reasoning as to the success or failure or each component and any validation information that is pertinent.

The current state of the UCAS development environment is made up of two web pages that form the foundation for access and activity selection. This activity selection process represent a key aim of this project completed and from a design perspective fulfils some of the design requirements stated previously in regards to easy and smooth access through identities and ability to start and complete remote activities and experiments online. Progressive development of the system will continue and will be refined again when preliminary Beta testing begins in the near future, testing will gauge opinionated and empirical data concerning appeal, usability and perceived academic quality. The UCAS was able to remain simplistic yet function through the continued research attained and guidance given on the subject of interface design. This guidance and support, from the RALfie team, also aided in the well thought out and detailed design of a the relational database, which allows information regarding any part of the interface, from users credentials to the current states of remote experiments, to be help and updated dynamically and safely. This safety is in regards to data integrity, which is helped to be enforced with strict rules or constraints on available input into the tables, eg. Integer values only. Flexibility of the database was retained, however, from building meaningful and function relations between tables and considering future developments and revisions of the interface and what they might require. This process of design and development was also aided by the AGILE development methodology, the functional blocks of code can begin simplistic and with continued testing and development, could be polished then combined into a more complex and robust algorithm. This methodology also allowed the progress for future developments to occur whilst not affecting functionality vital to the construction and purpose of the project.

The UCAS achieves a large amount of the overall project goals first set out by the RALfie team (see Figure 4.1 and 4.2), but it is yet to implement features that are currently incomplete or incompatible with the current release. Elements of gamification have not yet been utilised, this is due to the integration of pre-existing experiments, (which are to form the basis for activity functionality in Beta testing), which is ongoing.  Due to this the ‘activity completion’ component of the interface cannot be utilised to capture completion details, times and user achievements associated with the activity. It was for this reason Gamification was held back from the initial release of the UCAS. The functional components consisting of the constructivist learning approach, the ‘Maker’ and ‘Builder’ processes, which build upon a users knowledge by allowing them a chance to teach others, is not available to users at the current time, both due to tits lack of tests and ‘user proofing’ and the lack of available moderators or administrators, though still remain intact and active for current RALfie experiment creators and administrators to use. Implementing complex functional elements like the Maker process and extended user roles created hold ups and dead ends in the developments stage, that required the design requirements to be reviewed and changed, these factors coupled with the short timeframes of work and requirement for developmental assistance (due to lack of knowledge and experience), resulted in the incomplete status of these components.

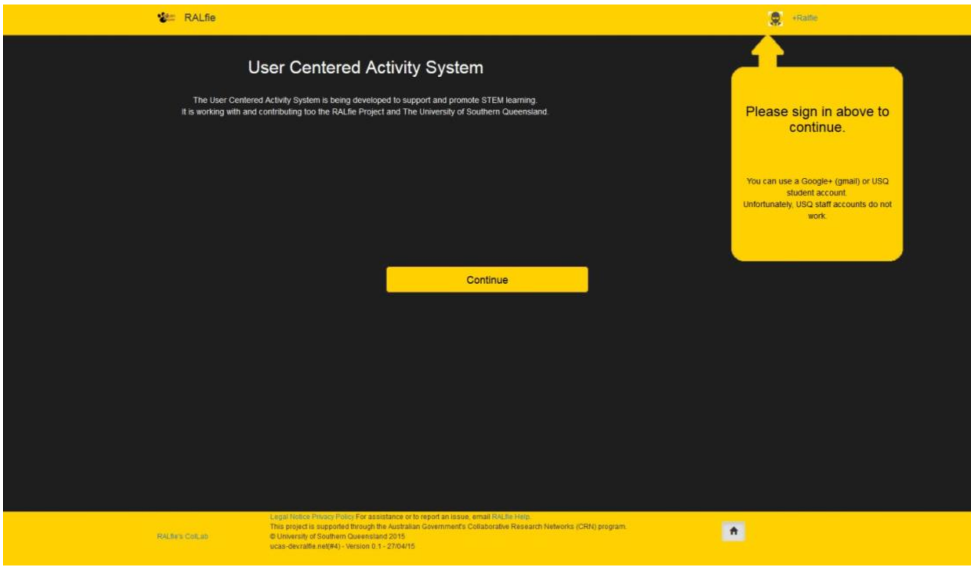



**Figure 4.1** – Current UCAS Login Page

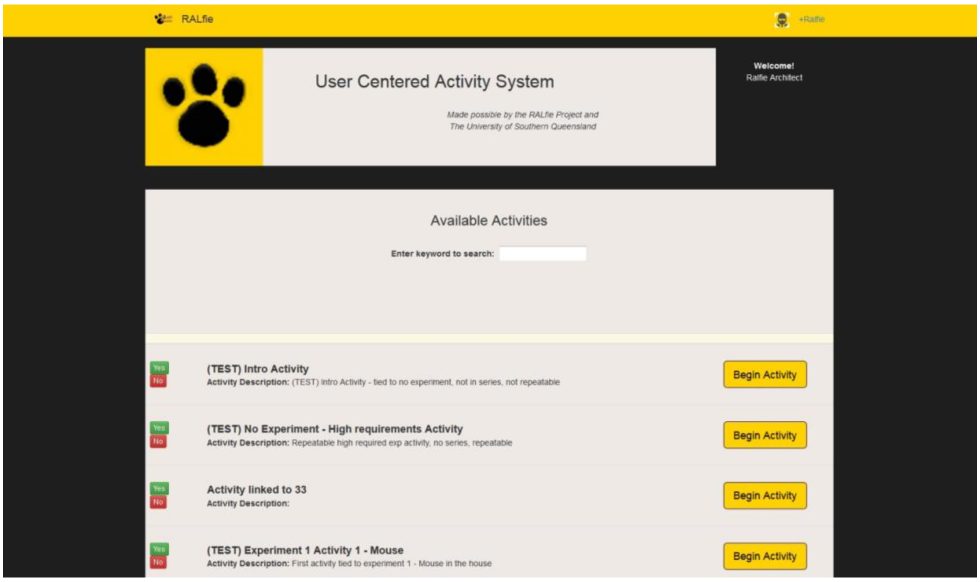



**Figure 4.2** – Current UCAS Home/Activity Page

## 4.3 Design Validation

During the validation process, each facet of the project's published works had to be detailed for the propriety of future developers, stakeholders, and for the critiquing of methodology that may lead to a more polished and well-rounded system. These details will cover technical depth information regarding the design, with respects to the coding and structure of the interface, this includes aesthetic, design based choices, as well as the integration of outside applications and supplementary elements. Focus will be made on the aforementioned constraints of access and coding standards used to employ a method of mutual access and will describe how each process is handled and how successfully it was carried out. Perceived failures and achievements of interface, gamification and architecture design and development will be derived through critical analysis of the current standards and preferred practice, this will be underpinned or contradicted based on the knowledge derived from the research phase of this project.

### 4.3.1 Interface Design Validation

Validating an interface is usually in regards to how visually appealling and functional it is, the two determinants of good interface design. The final colour schemes decided upon (Figure 4.1 and 4.2) were done to target two demographics, tertiary and primary students. Both function exactly the same but Figure 4.3mirrors the USQ colour scheme, whilst the latter aims at the younger demographic and is thusly based after the RALfie colour scheme. The composition of elements and their function purpose remains simplistic and driven towards a single purpose. Compared to older revisions of the UCAS (Figure 4.4) it can be easily seen that many elements have been refined to improve user accessibility, much of the unnecessary information was removed from each page, it was then restructured in a way that was more meaningful to the user. This composed of creating a typographical hierarchy, the most important information regarding each activity is kept at the top, the proceeding data is printed underneath in a smaller print, while least important factors on the page, access time and descriptive clusters, are given a measure of transparency in line with their addition to the page information.

Code that drives the functional components of the UCAS are seamless and invisible, this was achieved through robust coding of elements integrated with the database. Required information was stored and shared between pages of the interface through the use of HTML session variables, PHP functions and database access and update, easily retrievable yet unknown to the user. User authentication is simple and straightforward with helpful directional instructions and some information regarding the project. This page is the first one a user will see and as such should be made more enticing to the user whilst adding the required meaningful information to be enticing to potential users also. The activity selection page load seamlessly and does not show any information which is not meaning or accessible, compare to earlier designs which listed unavailable experiments even though they could not be accessed. With the help of JavaScript, the table can actively refresh its contents periodically, to keep the list up to date with availabilities, this process occurs in under a second and is largely unnoticeable to users. If these load times increase with increased traffic and use, it is imperative to ensure users are communicated the short delay.

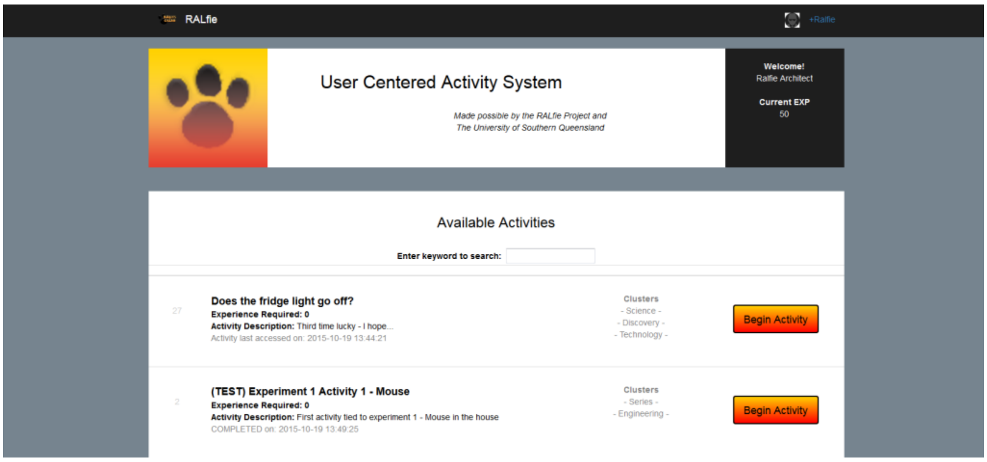



**Figure 4.3** – Alternate Colour Scheme for UCAS with Gamification elements

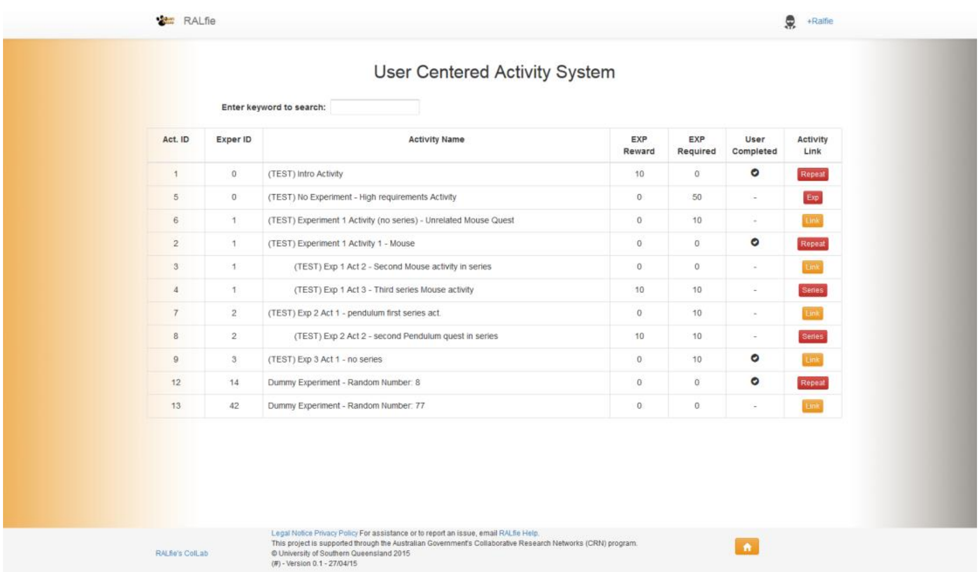



**Figure 4.4** – Early release of the activity selection page

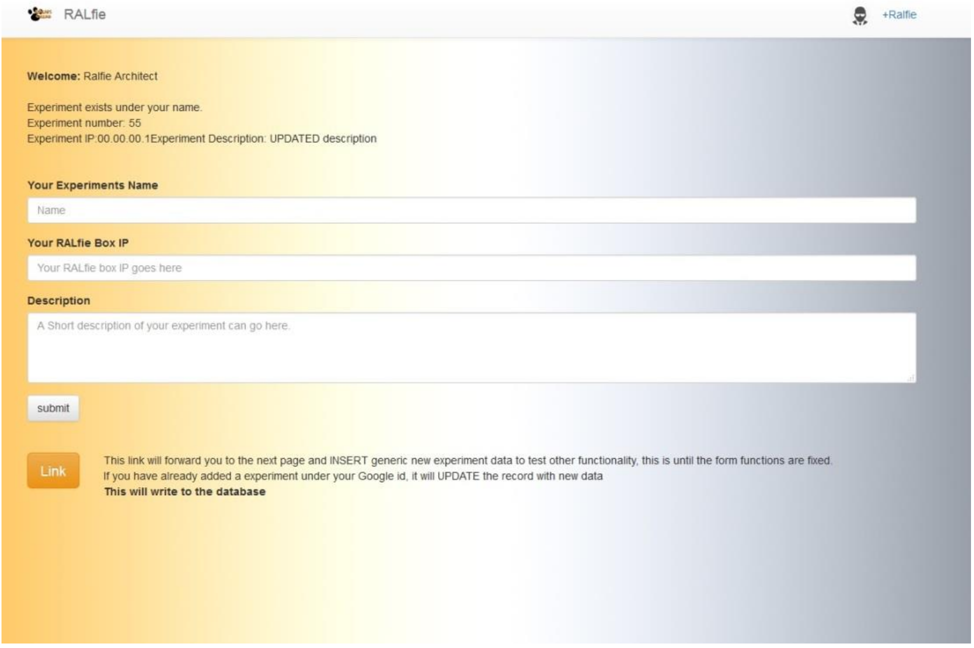



**Figure 4.5** – Early release of the Maker Process page

### 4.3.2 Gamification Integration

The integration of game-like elements to the web based interface known as the UCAS is a key principle of the project, the purpose of which is to enable the fostering and encouragement of STEM learning. Chosen by the gamification expert of the RALfie team, Dr. Lindy Orwin, were the elements to be included in the UCAS, which promised both instantaneous and cumulative forms of accomplishments. The elements chosen were awards (also called achievements or badges), experience points, which are coupled with a user levelling/growth system, which was postulated to grow into a role progression (user to builder to maker), there was also future plans to include a method for peer interaction and communication, which would most likely take the form of an online forum or similar medium. By keeping gamification element selection directed toward a single goal (demonstrating accomplishment) and limiting them in number, the UCAS falls within in previously noted professional recommendations, which strongly urge against the over-saturation of gamification in an academic environment. The achievements element serves a dual purpose in user response, as achievements can, and should, be both instantaneous (completion of first activity) and progressive (complete five activities). The same is true for the levelling or role progression aspects of the UCAS gameful elements, experience points can be earned for some activities and accumulate until reaches the next level, whereupon the process begins again, which can be easily seen to be a driving point in many gaming experiences and will perpetuate the continued use of the UCAS both in the short and long term.

The awarding nature of gamification can also aid in building of the communication and interaction skills between users of the system, who may be interested in sharing scores, experiences and ultimately helping one another. The structure and restriction of the gamified material also aids in the limitation of repetition of gamified elements within the system, limiting gratifications to give them a real sense of weight and purpose. To support this seemingly vital feature that will ensure the long life and use of this system a medium supporting user communication should be considered before public release.

Gamification elements, shown in Figure 2.7, illustrate the premise of the visual statement gamification will aid in applying. These elements aid in defining the educational preferences of each user whilst engaging their motivation towards milestones that hold both personal and academic meaning. The above figure also shows the inclusion of ‘clusters’, a defining process where activities can be ‘tagged’ with certain descriptive words relative to the activity in question. This process aids in both adding another search and filtering function to the activity list and encouraging user feedback, whilst adding a small gamification device, unobtrusive or overt, to support immersion and the ease of use. When active the gamification information, including values, descriptions and triggers are stored within a set of gamification tables within the supporting database, the tables can be edited freely to reflect the current user awards or achievements that are available to users. The method of execution of an award is called a ‘trigger’, this is a small contextual statements which outlines the requirements for an award to be granted, and can range from experience point gain, activity completion to mastery and speed, whatever details can be gauged by the system can be used to award users. To add flexibility to the final product, gamification elements, as well as, user roles and other extended functions have been coded to allow their simple removal or addition to the UCAS framework. Allowing future developers or users of the same framework as a basis for their application or as a teaching tool can easily tailor it to their specifications. As such the UCAS has been designed to function on varying levels of gamification. Further recommendations surrounding this design validation can be found in Chapter 6 – Recommendations.

### 4.3.3 Detailed Design Evaluation

The development of the UCAS required the integration of different coding languages and developmental styles that provided the required functionality. The design evaluation will aim to detail and dissect the coding methods and processes, related to current standards, used in the creation of the UCAS, whilst providing recommendations and pointing out potential shortcomings. The current release of the UCAS contains all the functional elements that are a necessity of the activity interface; that is the login page to obtain user identity and a main homepage, containing access points to currently available activities. Once coding and integration is completed these external activities will return back to the UCAS to summarise details of the completion and any points or awards that may have been earned. The key functional components of the aforementioned interface, described in previous chapters, can be found in the proceeding chapter showing components broken down into their specific coding functions. Conventions of naming were kept simple and were use throughout the design and coding process to add more meaning to functions and variables, terms like ‘act’, ‘exp’, ‘user’ and ‘game’ were key words used to communicate a connection with the associated aspect of activities, experiments, users and gamification with the database.The coding languages found in the majority of modern websites on the World Wide Web are HTML5, PHP and JavaScript and the success in which they are used are based upon their developer’s ability to combine these complementing styles to give the preferred effect.

Hypertext Meta Language, currently in its 5$^{th}$ revision, which is why it is referred to as HTML5, was key in building the visual foundations of the interface. By using a series of opening and closing tags, HTML can be used effectively to structure the view of a web page and controls certain values of display such as spacing, placing, font and responsiveness. With the introduction of Bootstrap, this process is added greatly by the addition of a large amount of pre-generated functions and interface elements, such as preformed navigations bars and animated buttons. Bootstrap also aids in the process of creating an easy organisational method that supports a responsive design. A measure of a pages responsiveness can be gauged by its appeal and restructuring when accessed through a personal smart phone, tablet or similar modern device and is fast becoming a requirement of all web spaces. Also vital in the design and display features of the interface are Cascading Style Sheets, a coding language very similar to HTML but used to govern the presentation (colours and default settings) of a document based in HTML, they allow global changes to webpage themes to occur easily. HTML is compiled from the host-side browser, meaning it is integral in the functionality that controls the current access period of the user, known as a session. This functionality plays a large part in the integration of authentication, utilising distinct host side operations to ensure continued and secure access.

```
//turn gamification elements on (1) or off (0)
$gamif = 1;

  if ($gamif){
      echo "<strong> Current EXP </strong> <br/>"
  }
```

**Figure 4.6** – Example of simple switch code used in conjunction with a case

```
<!-- HTML Coding Starts -->
    <div class="col-lg-3 pull-right">

<!-- PHP Coding Starts -->
        <?php

//PHP Function 'echo' printing strings as if they were HTML
            echo "<strong> Welcome! </strong> <br/>" .$user_quests['login'] . "<br/><br/> ";

        ?>

        </div>
```

**Figure 4.7** – Intermeshing of HTML and PHP coding languages

```
<!-- JavaScript function to actively show information after authentication is achieved -->
<script type="text/javascript">
function show_act(){
    $.post("./ajx/activities.php?list", {state: '<?php echo $token;?>'},
        function( data ) {
            $('#ActivityList').empty().append( data );
        }
    );
};
</script>

<!-- Build the construction surrounding the button -->
<div class="col-sm-4">
    <!-- Initiate the hiding of the continue button before authentication is achieved -->
    <div id="ActivityList"><h1></h1>
        <button id="page2" class="btn btn-ral btn-lg btn-block" onclick="javascript:gotoPage('page2.php');">Continue</button>
    </div>
</div>
```

**Figure 4.8** – JavaScript function followed by the reference made in HTML

Another staple of modern web design is the Hypertext Processor, known as PHP, this language is utilised to run procedural driven processes within the majority of web pages active. Through simple integration of PHP ‘tags’ (See Figure 4.7) the language can be easily integrated into HTML documents at any point. It is also flexible, in that is can process code as a function, an object or in a simple string of code where it is needed, adding to this flexibility is the ability to use HTML within PHP tags, utilising the ‘echo’ function, which prints text held within it, the same as standard HTML code.

Procedural PHP is required for accessing and updating of the database, it can be utilised to handle errors, manipulate or strip data before or after storage. Through the use of the ‘mysqli’ function, contained within PHP, a developer can set interactions with a database through the use of standard Subject Query Language (SQL). Further processes used consistently through the UCAS are the implementation of conditional loops; this aids in the sorting of information and performing repetitive tasks. The same can be said for case statements, which aid in error handling, filtering and conventional choice based coding selections through the use of a simple branching ‘if-then-else’ structure, common in many procedural or construction based coding languages which can greatly improve coding and data integrity, and is can be made easily readable. The process based coding techniques, coupled with database access form the basis of the list access and filtering steps, which queries for a list of activities only selecting those which are accessible and appropriate for the user. This filtering system of conditional statements has the easy ability to be extended upon in future releases, increasing the functionality when more user requirements are established and can be enforced. Currently the activity is checked for availability (through its applicable experiment, if necessary), before being evaluated based on currently user achieved pre-requisites, which may come in the form of experience level required or a previous activity in a series being completed. This process also fits within the specification for good interfacing, in regards to the keeping an interface uncluttered and unoccupied by inaccessible links or error messages.

Building PHP code into named functions can drastically reduce coding time and space by making certain chose processes reusable and with a certain level of flexibility. Functions, or objects, built within PHP can be code to accept variables or other functions as its input, and can be easily separated into their own functional blocks, making them accessible from any page required in the interface. Standards in coding and general consensus of current development in the field, state the beneficial use of functions when compared to long static blocks of code. Using functions to break down coding processes makes the code easier to read, understand and implement across multiple pages. By using the ‘include’ function, PHP documents can be kept separate from each other and accessed or changed independently of base code and supports a more modular system approach. The current UCAS release would benefit from the streamlining of service through collection and turning commonly used code into functions, this is especially true when considering the repetitiveness of such processes such as activity list access, sorting and refining.

JavaScript is the final coding method employed and is considered a necessity of design in an online environment as it aids in the creation of dynamic elements. It is important to note, however, that JavaScript does not delegate where objects are placed or even how, these specifications are controlled by the host environment (HTML). Through the use of JavaScript, the search function of the activity page could be utilised in real time, and the activity list itself could be kept updating through periodic ‘refreshing’ of the constituent information. A process which is capable of going unnoticed by potential users as the page integrity and look have not been compromised or lost for a moment. Based on an object orientated language, JavaScript favours the use of objects to build a class based and highly structured coding environment, a feature of the language that can intimidating or overwhelming for new users. The functionality provided by JavaScript also helps in the visual appeal of the web page, allowing smoother progressions, which may not seem noticeable or important (fading in and out of elements), but are important in building an appealing and immersive online environment. The use of JavaScript can be extended through an addition to the language called jQuery. Much like Bootstrap for HTML, jQuery complements the use of the JavaScript language, extending its usability whilst improving simplicity of code and allowing easier integrations with other other dynamically associated languages and techniques, such as AJAX. The complexity and rigid structure of JavaScript coding may require a higher level of understanding and practice to use it correctly and to suit the purpose of the project.

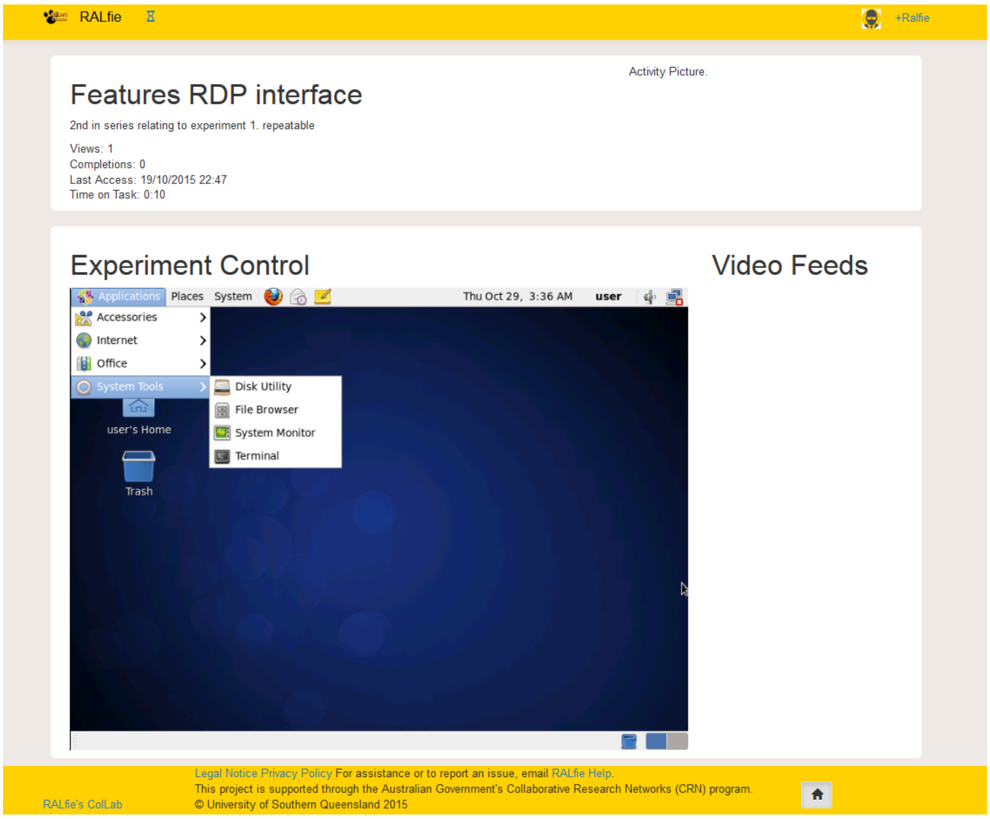



**Figure 4.9** – Current Progress on external activity integration

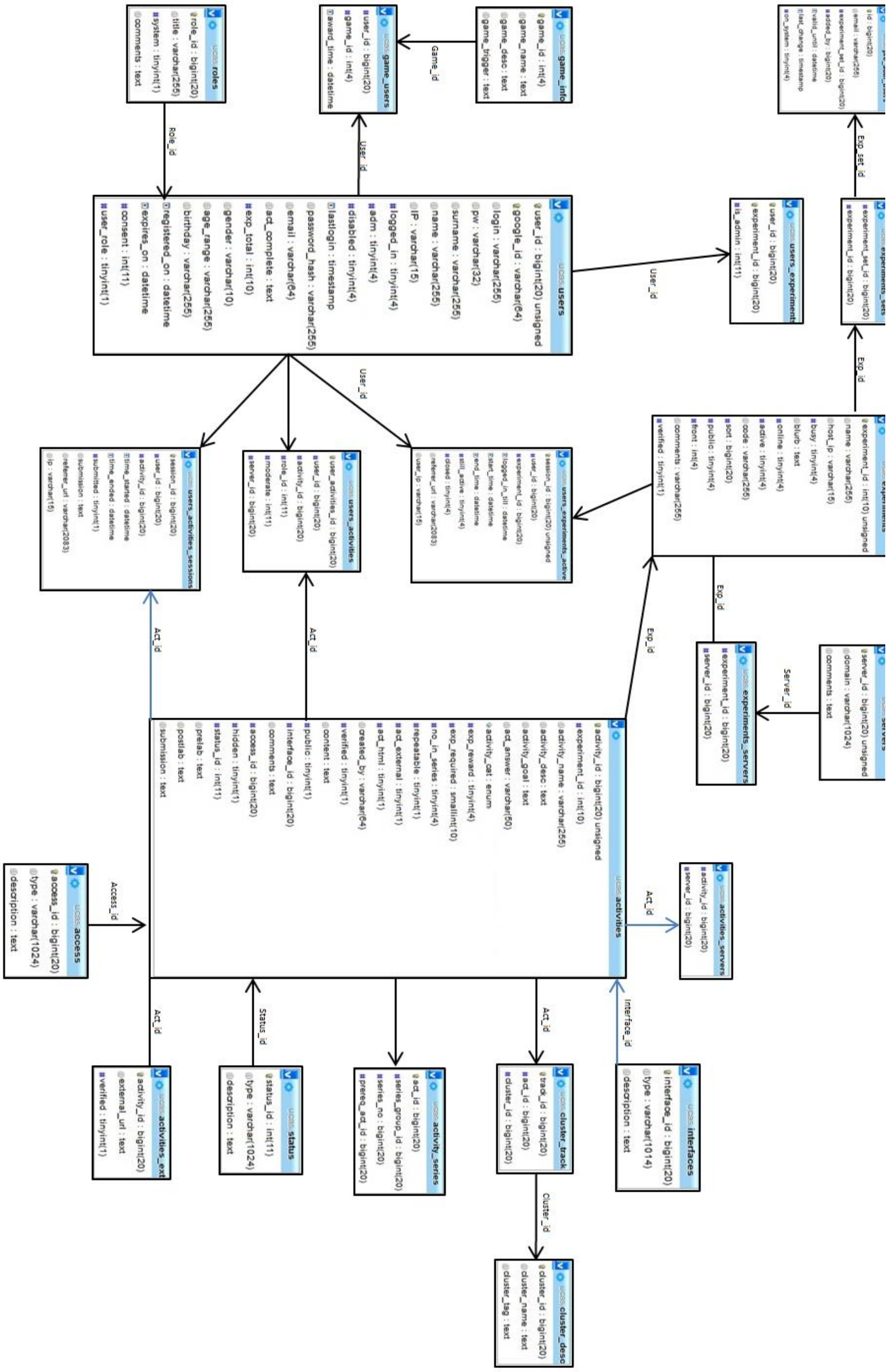



**Figure 4.10** – Detailed overview of relational database, tables and columns

#### 4.3.4 Database Design

The database underpinning UCAS is a series of tables linked by unique identifiers, known as the primary keys. This distinctive element is unique to a line of data within a table, and as such, can usually be used to reference or retrieve that table record. This ability to cross-reference information through constant relations forms the basis of data retrieval and control within the project. Good relational database design aids creation in the continued integrity of the information and keeping user load times short by separating non-specific or non-required information into separate tables whilst keeping it connected and relatable. As such it is important to decide upon the restrictions or rules surrounding database input early in the design periods. By restricting the column variable to a certain value and length (eg. An integer no bigger than ten) it aids in helping protect data and eliminate input of undesirable or malicious code to be input into the database. This case is especially true when using the ‘text’ type in database creation, when allowing the user to input text of any kind it is important to consider and implement an extended form of error handling to prevent any discriminate or indiscriminate acts of data corruption. The three predominant tables of the UCAS are User, Activity and Experiment, these tables hold the bulk of the hard-corded and dynamic information which is required in the functionality and descriptive values associated with the interface.

The users table contains information of both a descriptive and functional nature, concerning individual and distinct user identities. Upon authorisation into the UCAS, a new line is created in the users table, along with a unique id, which is tied to the google login information. This creates a system, with the help of externally linked tables, which can retain ownership and track a user’s progress in a variety of ways. This tracking can be done through the access and completion times associated with activities, which can aid in the validation of activities and to gauge users overall access time and perceived contribution or level of knowledge, this data is housed in the active user table. This user access tracking could also be extended to help determine an individual’s preference in terms of subject matter or learning style, allowing the integration of a more tailored experience for each user through directed marketing of suggested activities or events. The supplemental user tables also aid in allowing the onus of administration or moderation of activities and experiments to be delegated to multiple active users at the creators discretion.

The portion of the database holding the information regarding experimental data contains information ranging from descriptions of process and form to dynamically updated information relating to the accessibility and location of experiment apparatus. Descriptive values are usually available for users to understand the basic functionality and purpose of the experiment. Dynamically updated portions of these tables are done so in regards to accessibility of the experiment at that current time. Remote experiments allow only one user at a time to be connected at any time, this is due to the ability of the user to control certain features of the experiment interface during this time, namely the camera and any controls to do with the experiment itself. It is then far easier to limit the access to these experiments to 15 minutes for each session, thus allowing more users to access the material, in addition to, falling within the required timeframe for a standard active learning experience. These dynamic elements are held within the experiment tables as Boolean values (true or false) and are updated automatically through a logical process of the RAL, the system can also gauge the required end time of the current session, potentially vital to implement in the case of system communication. When a new experiment is entered into the Maker upload process it is entered into the database with a 'unverified' and 'inactive' status, this is due to current moderation requirements. In the context of this project experiments refer to the physical experiments set up in the Remote Assistance Laboratory, whilst activities refer to the learning process associated with it.

In comparison, an activity, held in the activity table, is more of a static collection of data that contains information concerning the activity, its access and achievable goal. It contains a large amount of descriptive data that would allow a user to complete the learning activity. This consists of a description of goals, the requirement for those goals to be completed and any potential gains. A separate table is used to hold any recent access or completion details of users; this includes time and date information which may be of use during validation and evaluation stages. The flexibility in the creation of an activity lies in its linking ability, an activity can be linked directly with an experiment, sharing its camera, controls, information and access restrictions, or it can be linked to an external web address or built from the base up using input into the required fields that displays in a standard template. The main activities table also records values based that assist with the filtering of activities through categorical lists, pre-requisite conditions and interfacing and access identifiers. These elements could form the base of a better user tailoring system. Much like the experiments table, activities are currently only moderated and verified, that is become active and visible, by administrative users, more autonomy in this process could greatly reduce human input required to keep UCAS up to date.

Information on the rewarding elements of the UCAS is kept updated with the 'game' tables, which are displayed to the user through the interface. These details include descriptions of the awards and the triggers of their achievement, as well as, data relating to the distinct time and date each award had been triggered by an individual user. The experience values to do with the gamified elements of level progression are held within the user table, allowing for direct correlation with each identity, whilst the requirement and reward values for each associated activity are kept within the activities table. Defining terms, clusters or tags within the UCAS, are kept track of in a similar way; each is tied to a descriptive and identifying value which is then tied to the activity through external tables.

### 4.3.5 Future Design Implementations

The current release of the UCAS, in regards to its extended functionality and form could benefit from a number of design changes that would streamline current implementations. Breaking down working PHP code into functions, then further separating common and recurring functions of the interface into individual PHP documents would cut down on a lot of unnecessary code and allowing certain processes to become global (ie. be able to accessed and used by all parts of the interface). The current process and related workflow for the Builder process requires refining. As seen in Figure 4.11 the process was broken up into a number of easily manageable steps, but more care has to be taken in the design respects, especially in regards to smooth integration of pages or elements and also the cognitive and aesthetic based elements. In regards to the Maker element, more error handling, upload validation checks and user testing are required before the process can be implemented into the design. The future implementations to UCAS should focus more on its desired and potentially grand purpose, with a user base the UCAS could reach an absolutely huge audience and the continued design refinements and specification will undoubtedly be continually derived over the course of its life.

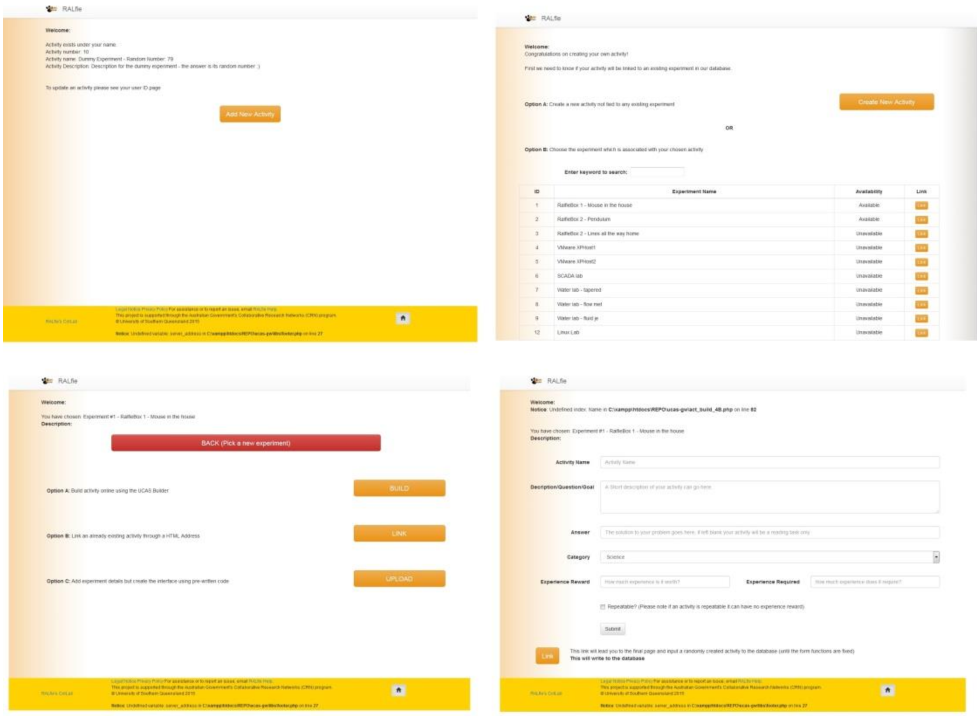



**Figure 4.11** – Early UCAS revision showing Activity Builder Process

## 4.4 Consequential Effects

This creation process can be fraught with moral and ethical issues based around information sharing and production constructed on certain models or ideas, made worse by the inherent anonymity and expanse of the World Wide Web. Legal issues can arise especially in regards to intellectual proper or copyright material, in addition to those related to any consequential effects of the interface. The UCAS environment fosters a safe environment for its users, and to do this certain safety risks must be identified and controlled, this process will occur adhering to the ethical and moral guidelines of engineering and that of a teaching institution. Control measures directed towards certain issues can be put in place to minimise are potential for harm or damage to occur.

### 4.4.1 Legal

Legal issues arose recently for the Remote Access Laboratories (RAL) project with the publishing of a patent by Boise University, Idaho [6]. This patent outline a non-linear quest-based learning methodology that comprised of a set of quests based on a certain educational curriculum. Since its publishing, special consideration would be needed to ensure no material deemed intellectual property could be infringed upon [6], [11]. This is a moot point however, mainly due to the fact the RALfie team have design and development documents that predate the date of patenting. The interface being created for RAL, the UCAS is directed at students studying externally or in remote locations it has the ability to open up to the larger community base and thusly a larger knowledge base of physical experimentation. Furthermore the RAL project plans to make this system architecture open source at the finality of the process, meaning they will generate no revenue from it and it can be used freely by any person or organisation.

Given the current state of legality in regards to the World Wide Web, it would seem quite prudent to introduce some form of user agreement into the authorisation steps of the UCAS. This agreement would require user acceptance and would stipulate a certain level of conduct that must upheld by the user. Details of this code of conduct would be required to include the purpose and drive of the UCAS, as well as, the rules surrounding appropriate language/behaviour, malicious attacks or any other conceivable element which may detract from or destroy the interface and its usability. Punitive measures for such violations, such as exclusion, also referred to as ‘banning’, would require the implementation of administrators to enforce the protocol. These measures are beneficial to put in place not only for the protection of users but also to protect the university and any associated people or organisations from potential legal consequences.

### 4.4.2 Ethical Responsibilities

*“Practise engineering to foster the health, safety, environmental and economic considerations into the engineering task”* (Engineers Australia Code of Ethics 4.2)

The safety issues exist in this project where users under the age of 18 have a potential to gain access to offensive or inappropriate material [11]. Because of this there is an inherent need to moderate some aspects of the process whether it be by administrators or through skilled development of the back end system. This moderation would need to exist in the maker and activity upload areas of the interface; this is the only area where users of a certain level can upload information that can become easily accessible after completion. It is suggested that including a swearing search tool on all uploaded textual material will eliminate any offensive language being input into activity and experiments listings. To help in this moderation a section of the user acceptance agreement should outline the unacceptability of these actions to the users under threat of expulsion from interaction with the website. The same moderation would need to extend to any images uploaded by the users, or video fed from a user’s maker setup, it is for these reasons that image and video feeds should be required to be approved before being seen by the larger community. This process could be aided by the introduction of a third-party ‘net nanny’ application that can scan user input fields before submission to make sure they do not contain any inappropriate language, links or images.

### 4.4.3 Sustainability

Sustainability is the evaluation of our world ecology in its capacity to endure our existence and continue to support of all living species on Earth. In this vein it is extremely important to consider any impacts the system may have on the environment, society or the economy. Constituent physical elements of the UCAS, particularly the remotely accessed laboratories, were already in existence but were thoroughly underutilised. The web based elements and construction applications used in development of this interface were free of charge either through open sourcing or the required application was in support of an education initiative. The process of making this interface open source and easily accessible also adds an element of sustainability to the project [11] in that its existence could save future architects time in constructing a similar learning system. The web based nature of this practical experiment interface transcends location and supports communications and by putting forward the principal concepts and knowledge surrounding the UCAS, future developers can use it as a basis to work from whilst building on and modifying to create their own system. This promotes further involvement from the community, fostering a great access of knowledge to all people who wish to access it. This interface seemingly falls within the sustainable guidelines, as it helps in utilising pre-existing infrastructure and data processes to repurpose them into an interactive learning tool.

## 4.5 Safety

When undertaking any physical task involving moving parts or electricity there is always a slight chance for harm to come to the user. Thusly the safety concerns for this project exist around the maker process. To limit the amount of risk any user has whilst trying to complete an experiment a starter kit is supplied with the Maker registration, among the items provided is a small Direct Current power supply, allowing nearly instant progression on a first experiment to be made. This was also done to limit the amount of dangerous conditions to which Makers are exposed, the Lego Mindstorms battery has very few open terminals and is less likely to incur injury through tiny electrical shocks or tingles in comparison to a standard circuit constructed on an electrical bread board which may contain many exposed energised parts. The battery pack itself, however, remains a source of power and thus a storage device for a great amount of potential energy. To avoid potential catastrophic events, proper care, handling and use should be clearly outlined to the any potential user. Importance was placed upon safety within this project, as it would be predominantly displayed to the wider community; thus it was a requirement to ensure documents contained sufficient information to cover all the safety aspects that are relevant. Through the implementation of safety precautions, this project, aims to limit the exposure of unsuitable material and the potential for harm to occur.

#### 4.5.1 Risk Assessment

| **Risk Description** | **Risk Significance** |
|---|---|
| Potential for cuts or lacerations caused by small electronic parts whilst users construct their own experiment<br><br>People at risk - user | Occasional likelihood – Minor injury |

| **Short term controls** | **Long term controls** |
|---|---|
| The lack of inclusion of any electronics components within the Maker kits, encourage users not to build circuitry unless trained or experienced. Inclusion of a safety document outlining potential for harm to be caused. | Create a process where users can safely learn the methods of electronic handling and assembly |

| **Risk Description** | **Risk Significance** |
|---|---|
| Potential for electrical ‘shocks’ or ‘tingles’ from the DC battery supply (Lego Mindstorms)<br><br>People at risk - user | Rare likelihood – Minor injury |

| **Short term controls** | **Long term controls** |
|---|---|
| Supply user information regarding the safe handling and of current supplying devices. | Consider alternative supplies, housings or other safety measure to help protect users. Create a process to educate users on electrical safety. |

| **Risk Description** | **Risk Significance** |
|---|---|
| Potential failures of a lithium ion battery pack (Lego Mindstorms), known failures include explosions and fires.<br><br>People at risk – all surrounding people | Very rare likelihood – Major injury, major destruction, possible death |
| **Short term controls** | **Long term controls** |
| Supply and refer to the constituent Lego safety information and precautions regarding the battery. This includes workable environments and safe handling advice such as proper charging and appropriate storage | Consider removing battery pack from user Maker kits and supplying an AC adapter instead, eliminating the risk or potential explosion or fire. |

| **Risk Description** | **Risk Significance** |
|---|---|
| Exposure of users to inappropriate material<br><br>People at risk - user | Occasional likelihood – Minor injury |
| **Short term controls** | **Long term controls** |
| Enforce the user agreement and focus on the desired behaviour and language which will be required for participation, continual manual moderation of all uploaded material | Put a system in place to monitor communications and uploads and prevents it from being shared or being easily accessible to all users |

| **Risk Description** | **Risk Significance** |
|---|---|
| Potential for users with malicious intent to hack or corrupt the web based interface<br><br>People at risk – all users | Very rare likelihood – Major destruction of equipment |
| **Short term controls** | **Long term controls** |
| Continually and concisely monitor the authorisation process, ensure users are following guidelines through manual tracking of suspect files. | Implement a moderations service that can add addition error handling and authorisation based protection from coding attacks or illegal access attempts. Confirm security of associated table access properties |

## 4.6 Resource Constraints

The initial resource requirements for the UCAS project were very minimal, with most integrations or tools only requiring the time. Before construction could begin the repository, database and webserver needed to be implemented to provide a testing ground and eventually integrate into the existing remote access interface. These costs were kept to a bare minimum by utilising free and open source applications and providers, or in the case of the webserver, utilise infrastructure already in place. To alleviate all costs to the development program a similar approach was taken, sourcing free applications to edit, compile and test parts of the interface whilst development continues. To reduce costs when using the UCAS, it can be run from a locally held database.

## 4.7 Conclusions

Analysis suggests the key objection of this project has been fulfilled, that is the implementation of user interface capable of allowing user access to remote experimentation. Secondary or extended goals of the project, mainly the completion of the extended user roles and the Maker/Builder processes; the frameworks exists for these elements but until further testing and development can occur they cannot be fully implemented. Some research outcomes are still yet to be validated, these relate to the UCAS as a potential teaching tool and the ramifications, if any, of the addition of gamification elements.

# CHAPTER 5 – RESULTS AND DISCUSSION

## 5.1 Introduction

As mentioned in earlier chapters, the current state of user testable code consists of the user authentication and activity selection screen, integration of external experiments is ongoing from outside sources and will be completed before Beta testing can begin. Due to the subjective nature of appealing and gratifying elements, it will be difficult to gauge some aspects of user appeal and enjoyment. The results and discussion will illustrate the process that will occur to obtain qualitative and quantitative data from users testing the system, and will outline potential improvements and where they can be made. An information collection process that is already implemented in the UCAS will retain information relating to activity access and completion times as well as other important information. The presence of meaningful data derived from testing can be utilised by the UCAS developers and could translate to help in refining processes, visuals and provide a meaningful discussion topic for the associated stakeholders.

## 5.2 Results Analysis Methodology

Current methodology to be employed in Beta testing is still under discussion by the RALfie team, though of the most effective methods of gauging feedback, it is common to begin with a simple post use survey. This type of results driven testing provides very general feedback of the interface and its usability and aesthetics, a necessary requirement for any successful and long lived user interface. A series of pre and post tests can aid in gauging more in-depth and directed feedback, ranging from subject material retention to driven psychological response, as well as, continue to gauge the users opinionated view of the interface. An example of further testing procedures that may be employed in the testing process include time-on-task which can aid in accessing the amount of time each student has accessed an activity for; helping to gauge individual speed of use, and overall difficulty of the activity.

## 5.3 Future Developments/Results

Future testing of the UCAS will be required to ascertain certain user responses and effects with a more focused and direct intention. Testing should continue when gamification elements are introduced to the system to gauge user acceptance and enjoyment. These tests will more likely take the form of a series of pre and post-tests, aimed at a user's ability to use the system, critically think, as well as find worth in the academic merit and gratifying elements. This testing should also be focussed on the gained knowledge of STEM subjects.

# CHAPTER 6 – CONCLUSIONS

## 6.1 Project Conclusions

The original aim of the development of the User Centered Activity System was to create an easily accessible user interface that would allow and encourage access to remote experimentation in Science, Technology, Engineering and Mathematics subject fields. Some of these technical objectives have been met, the physical work done in design, development and validation has produced an interface capable of displaying and serving available activities and experiments which can be accessed and completed freely. These are, at this stage, primarily pre-existing activities which are undergoing a more complete sense of integration by external developers. With this integration remaining incomplete it is impossible to yet neither employ and test the gamification elements, nor gauge the associated times and dates the experiments are completed.

Some processes and function of the UCAS still remain unimplemented due to an incomplete or incompatible status. This is in part due to a lack of design foresight regarding the complexity and requirements of certain processes, especially the Maker and Builder roles, it also suffered from a deficit of knowledge of the developer constricting already tight timeframes. Although the ability to access the Maker and Builder construction tools is not yet accessible to users, administration staff and students within RALfie are still able to use and provide constructive feedback about the process with safety ensured. Initial testing of the interface could not begin before the project was completed but the development of the UCAS will be ongoing from the support of the RALfie team as well as associated and interested community members.

## 6.2 Research Conclusions

The core aims of the UCAS are centered on the encouragement of STEM learning. For the advancement of Australian and world research and development, it would be highly advantageous to encourage more students towards a career in the STEM fields. The research and associated methodologies illustrate the complementary nature of the utilised factors in teaching and motivation used in the development of the UCAS whilst underpinning the requirement for such work to continue and expand. Conclusions could be drawn of the requirement for added focus on STEM subject development in primary and secondary education, drawing the facts of the specific constraints and necessities in correct application. The process of active learning shared similar requirements, most notably that of guidance and interactivity and was a teaching methodology found extremely purposeful and relevant to the project aims and the technical work being carried out. To help transition a form active STEM learning from classroom based to an online interactive experience elements of achievements and purposeful real world goals were added to motivate users. The gratifying elements included, known as gamifications, though seem beneficial in theory, are not fully backed by a compendium of supporting research, generally because it is a new term, and fundamentally because collected information can sometimes be difficult to make relatable.

In terms of a research project, the material provided frames the UCAS; guiding its design and development, but it also gives rise to the potential ramifications this project may pose. It can be easily seen that this interface has the potential to add a large amount of STEM related material which is freely and easily accessible, supporting free and meaningful education. The intention of gamification is the continued guidance and encouragement of the STEM learning in its users; an intention shared by the RALfie team and indeed many education professionals. The open and online nature of the interface allows for an easy method of communication to be implemented between peers, thus will allow for an extended range of user help and development of critical analysis and communication skills. The UCAS aims to create a positive learning environment, a process which theoretically falls within the teaching and learning guidelines, fostering education whilst protecting participating students. This project, and indeed the entire RALfie initiative, is driven through academic purpose, under sustainable, ethical and legal guidelines, for the betterment of people worldwide.

## 6.3 Future Work & Recommendations

Community driven aspects of the UCAS, that support positive and helpful communications between users could definitely be given more focus. This implementation could give rise to the introduction of ‘mentor’ or ‘professional’ role within the community, thus a larger source of information and feedback. The integration of an online forum or similar communications tools would also satisfy the intrinsic needs of the ‘helper’ types of gamers, said to be around half of all online gamers worldwide, to solve problems and provide assistance to other users. Logical progression from that point would be to implement an achievement process or inclusion for people who help other users more, this information could also be very valuable in the process of testing and evaluation as data could be recorded on each user discretely.

Further work would consist of continued refinement into the design of the interface to make it more visually appealing and dynamic. This would include the refinement and extension of current functions that can accommodate and are directed towards more user tailored elements, whether it be to preference or simple control over colour schemes or information displayed. This work could progress into the introduction of an extended experience system, breaking up the current total experience a user has into the four separate experience subsections (Science experience, Technology experience, Engineering experience and Mathematics experience). This will allow for better defining of an individual users strengths and interests and may allow for further tailoring of the interface based on this data.

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# Appendix A – Project Specification

**University of Southern Queensland**
**School of Mechanical and Electrical Engineering**

**PROJECT SPECIFICATION**

ENG4111/ENG4112 – Engineering Research Project

**"Developing an Activity-Based User Interface for Remote Experimentation for Science Education in Schools"**

Supervisor: Dr. Alexander Kist

Aim: To design, implement and evaluate a quest-based activity interface for the RALfie access system

Programme: (Issue C, 18/03/15)

1. Undertake a basic requirements analysis, identify initial use cases (potential experiments) and develop a project specification.

2. Research current coding standards and best practice in web user interface design using HTML5, PHP, CSS and Javascript.

3. Undertake a literature review covering STEM learning, Remote Access Laboratories, gamification and quest based activities.

4. Talk to stakeholders and establish roles in the development process.

5. Design the architecture of a user interface for the RALfie system

6. Plan, develop and design the system following an AGILE development model. During each iteration this will involve designing and developing a working prototype, followed by testing and integration.

7. Document all steps of the project and write an academic dissertation on the research

As time permits:

1. Implement addition features
2. Undertake usability testing

_________________________ (Student) _____________________________ (Supervisor)

Date: _______________ _________________

# Appendix B – Detailed Coding Information

```
<script type="text/javascript">
    function show_act(){
        $.post("./ajx/activities.php?list", {state: '<?php echo $token;?>'},
            function( data ) {
                $('#ActivityList').empty().append( data );
            }
        );
    };
    </script>

 <!-- Format User Login -->
 <div class="containter" style="text-align:center; color: white">
     <div class="col-lg-9">
         <div id="div1">
             <br/>
             <h2>User Centered Activity System</h2>
         </div>
         <br/>
         <div id="div2">
             The User Centered Activity System is being developed to support and promote STEM learning. <br/>
             It is working with and contributing too the RALfie Project and The University of Southern Queensland.
         </div>
     </div>
     <!-- Show login instructions -->
     <div class="col-lg-3" id="div3" style="color: black; background-image: url(/img/textbox1.png); height: 400px; width: 300px; background-size: 100% 100%; opacity: 1.0;">
         <br/>
         <br/>
         <br/>
         <br/>
         <br/>
         <strong><h3> Please sign in above to continue. </h3></strong>
         <br/>
         <br/>
         <br/>
         You can use a Google+ (gmail) or USQ student account.
         <br/>
         Unfortunately, USQ staff accounts do not work.
     </div>
     </div>
     <br/>
     <div class="container">
         <div class="col-sm-4"></div>
         <div class="col-sm-4">
             <!-- Initiate the hiding of the continue button before authentication is achieved -->
             <div id="ActivityList"><h1></h1>
                 <button id="page2" class="btn btn-ral btn-lg btn-block" onclick="javascript:gotoPage('page2.php');">Continue</button>
             </div>
         </div>
         <div class="col-sm-4"></div>
     </div>
```

**B.1** – Functional coding for User Login page (kept in colour for readability, complete listing below)

```
<!-- Create table for Activities -->
<div class="container main">
    <div class="row nopadding" style="text-align: center">
        <br/>
        <h3 style="text-align: center">Available Activities</h3>
        <br/>
<!-- Add search field and JavaScript functionality -->
        <label for="search"><strong>Enter keyword to search:   </strong></label><input type="text" id="search"/>
<!-- Create activity table format -->
        <table class="table nopadding" id="tblData" style="text-align: left">
                <tr>
                    <td class="col-md-1" style="text-align:center"></td>
                    <td class="col-md-6" style="text-align:center"></td>
                    <td class="col-sm-3" style="text-align:center"></td>
                    <td class="col-sm-3" style="text-align:center"></td>
                </tr>
                    <tbody>
                            <!-- Fill the table with 'activities' table  -->
                           <?php
                           //populate activities into array
                            if(mysqli_num_rows($query) > 0){
                                while ($row = mysqli_fetch_array($query)){
                                    //check certain clauses to make sure activity is usable, otherwise 'continue'

                                    //set up variables
                                    $act_id = $row['activity_id'];
                                    $user_id = $user_quests['user_id'];
                                    $null_endtime = strtotime('0000-00-00 00:00:00');
                                    date("Y-m-d H:i:s", $null_endtime);
                                    $is_comp = 0;
                                    $is_access = 0;

                                    //setup query to check for access
                                    $access_q = mysqli_query($conn, "SELECT * FROM users_activities_sessions WHERE user_id = $
                                            . "AND activity_id = $act_id ORDER BY time_started DESC");
                                    if(mysqli_num_rows($access_q) > 0){
                                        $access_row = mysqli_fetch_array($access_q);
                                        $is_access = 1;
                                        $trail_comment = "Activity last accessed on: " . $access_row['time_started'];
                                        //access has been achieved, but has completion? - setup query for complete check
                                        $comp_q = mysqli_query($conn, "SELECT * FROM users_activities_sessions WHERE user_id =
                                                . "AND activity_id = $act_id AND time_ended != $null_endtime ORDER BY time_sta
                                        if(mysqli_num_rows($comp_q) > 0){
                                            $comp_row = mysqli_fetch_array($comp_q);
                                            $is_comp = 1;
                                            $trail_comment = 'COMPLETED on: ' . $comp_row['time_ended'];
                                        } else {
                                            $is_comp = 0;
                                            $trail_comment = 'Activity last accessed on: ' . $access_row['time_started'];
                                        }
                                    } else {
                                        $is_access = 0;
                                    }

                                    //check if in_series, and if so, if pre-req is met
                                    if ($row['no_in_series'] == 1){
                                        //create query to track down pre-req
                                        $series_q = mysqli_query($conn, "SELECT * FROM activity_series WHERE act_id = $act_id'
                                        $series_row = mysqli_fetch_array($series_q);
                                        $series_prereq = $series_row['prereq_act_id'];
                                        //create query to check if pre-requisite completed
                                        $prereq_q = mysqli_query($conn, "SELECT * FROM users_activities_sessions WHERE user_ic
                                                . "AND activity_id = $series_prereq AND time_ended != $null_endtime ORDER BY 1
                                        if ($series_prereq != 0){
                                            if(mysqli_num_rows($prereq_q) > 0){
                                                //prereq complete
                                            } else {
                                                continue;
                                            }
                                        }
                                    }

                                    //if gamification is active, check for sufficient exp
                                    if ($gamif){
                                        if ($user_quests['exp_total'] < $row['exp_required']){
                                            continue;
                                        }
                                    }
```

**B.2(a)** - Functional code for Activity Selection Part 1 (complete listing below)

```php
//build table of activities
//POPULATE FIRST COLUMN - ADMIN
echo "<tr>";
echo "<td style=\"text-align:center; opacity: 0.2\">";
//display user admin features (if applicable)
if ($user_quests['user_role'] == 4){
    echo "<br/>";
    echo $act_id;
    echo "</td>";
} else {
    echo "</td>";
}

//POPULATE 2ND COLUMN - ACTIVITY DETAILS
//display activity information
echo "<td> <br/><strong><font size=\"4\">" . $row['activity_name'] . "</strong></font>";
if ($gamif){
//display gamification information if active
    echo "<br/><strong>Experience Required: ". $row['exp_required'] ."</strong>";
    if ($row['exp_reward'] > 0){
        echo "  - - - -  <strong>Experience Reward: ". $row['exp_reward'] ."</strong>";
    }
}
echo "<br/>";
//display standard activity information
echo "<strong> Activity Description: </strong>" . $row['activity_desc'];
if ($is_access == 1 || $is_comp == 1){
    echo "<br/><p style=\" font-size: 100%; color: gray\">". $trail_comment ."</p>";
} else {
    echo "<br/>";
}
echo "<br/> </td>";
//POPULATE 3RD COLUMN - TAGS/CLUSTERS
echo "<td style=\"text-align:center; opacity: 0.5\">";
//create query for clusters
$cluster_q = mysqli_query($conn, "SELECT * FROM cluster_track WHERE act_id = $act_id");
if(mysqli_num_rows($cluster_q) > 0){
    echo "<br/>";
    echo "<strong> Clusters </strong>";
    echo "<br/>";
    while ($cluster_row = mysqli_fetch_array($cluster_q)){
        $cluster_id = $cluster_row['cluster_id'];
        $tag_q = mysqli_query($conn, "SELECT * FROM cluster_desc WHERE cluster_id = $cluster_id");
        $tag_row = mysqli_fetch_array($tag_q);
        echo $tag_row ['cluster_tag'];
        echo "<br/>";
    }
}
echo "</td>";

//POPULATE 4TH COLUMN - BUTTON LINKS
//display access button and link depending on whether it is 'html' link or not
if ($row['act_external'] == 1){
    echo "<td>";
//Discover appropriate activity link and display it
    $ext_act = mysqli_query($conn, "SELECT * FROM activities_ext WHERE activity_id = $act_id");
    $ext_url = mysqli_fetch_array($ext_act);
    echo "<br/><br/><button class=\"btn btn-ral btn-lg\" "
    . "onclick=\"window.open('".$ext_url['external_url']."');\">Begin Activity</button><br/>";
    echo "</td>";
    echo "</tr>";
} else {
    echo "<td>";
    echo "<br/><br/><button class=\"btn btn-ral btn-lg\" "
    . "onclick=\"javascript:gotoPage('activity_standard.php?id=".$row['activity_id']."');\">Begin Activity</button><br/>";
    echo "</td>";
    echo "</tr>";
}
```

**B.2(b) -** Functional code for Activity Selection Part 2 (complete listing below)

```
.div.btn-group {
    margin: 10 auto;
    text-align: center;
    width: inherit;
    display: inline-block;
}

.img-responsive {
    margin: 0 auto;
}

.img_container {
    position:relative;
        width: inherit;
    display:inline-block;
    text-align:center;
}

body {
    padding-top: 55px;
  }

.bg-charcoal {
  background-color: #1e1e1e;
    color: #fff;
}
```

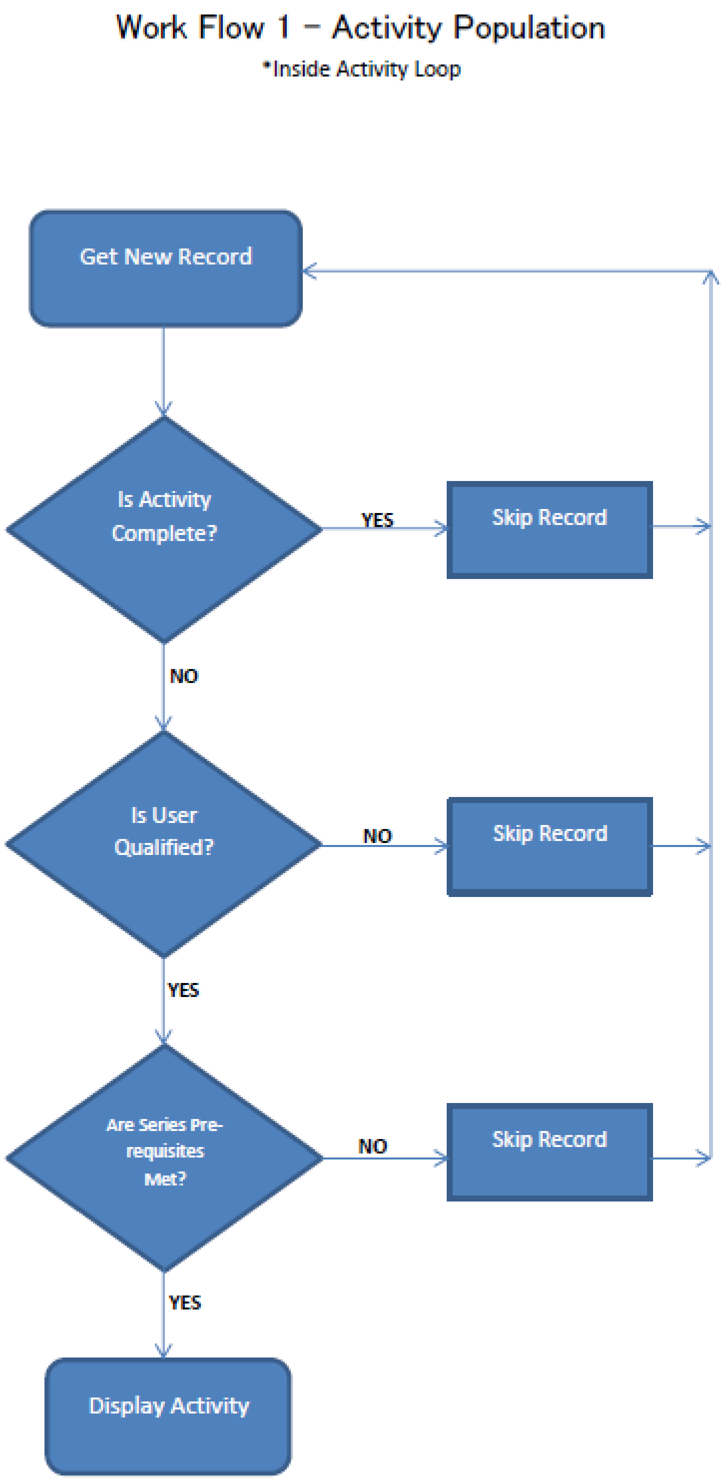
```
.bg-yellow {
  background-color: #ffd100;
}

/* Sticky footer styles
-------------------------------------------------- */
html {
  position: relative;
  min-height: 100%;
}
body {
  /* Margin bottom by footer height */
  margin-bottom: 100px;
}
.footer {
  position: absolute;
  bottom: 0;
  width: 100%;
  /* Set the fixed height of the footer here */
  height: 100px;
  background-color: #f5f5f5;
}
```

**B.3** – UCAS Cascading Style Sheet (USQ Theme)

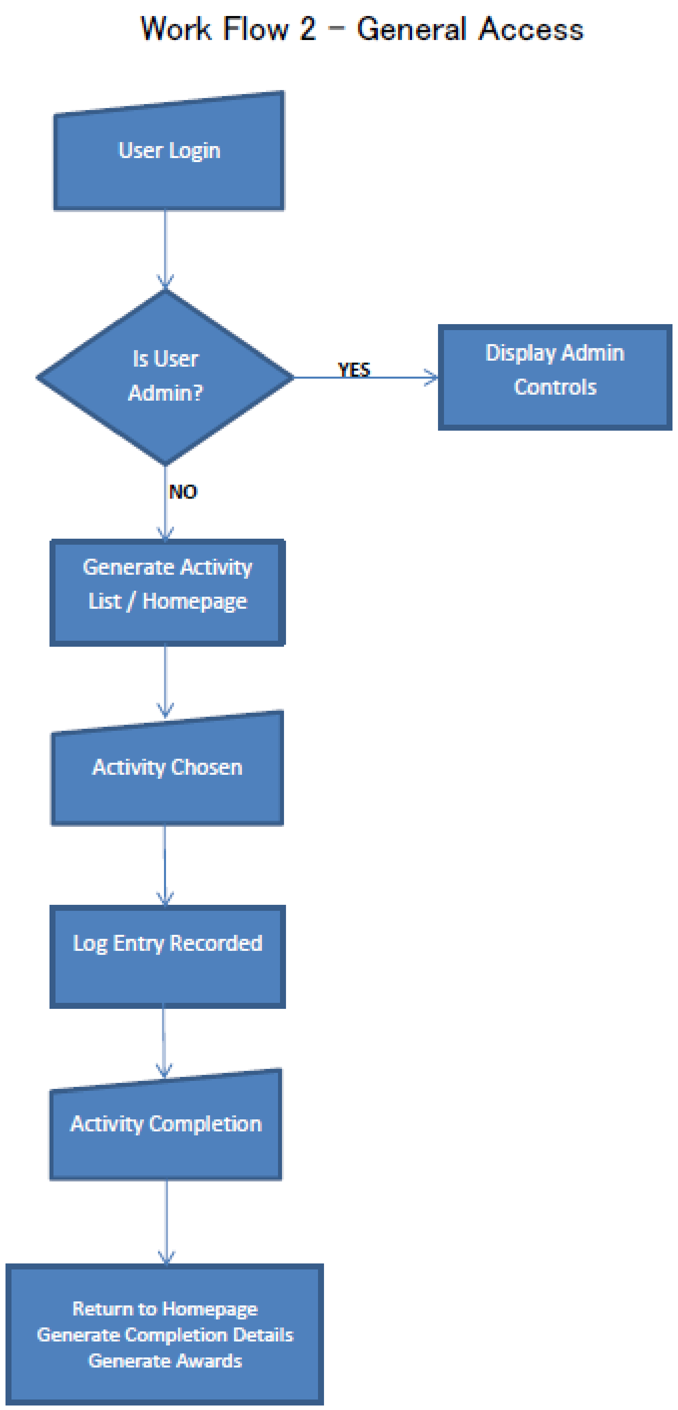
```css
.div.btn-group {
    margin: 10 auto;
    text-align: center;
    width: inherit;
    display: inline-block;
}

.img-responsive {
    margin: 0 auto;
}

.img_container {
    position:relative;
        width: inherit;
    display:inline-block;
    text-align:center;
}

body {
    padding-top: 55px;
  }

.main {
      background-color: #efe9e5;
  }

.bg-charcoal {
  background-color: #1e1e1e;
}

.bg-yellow {
  background-color: #ffd100;
}

.btn-ral {background: rgba(255, 0, 0, 1);
        background: -webkit-linear-gradient(top, rgba(255, 208, 0, 1) 0%, rgba(255, 0, 0, 1) 100%);
        background: linear-gradient(to bottom, rgba(255, 208, 0, 1) 0%, rgba(255, 0, 0, 1) 100%);
        border-color: rgba(0, 0, 0, 1);
        color: rgba(0, 0, 0, 1); font-size: 18px;
        border-radius: 4px;
        border-width: 2px;
}
.btn-ral:hover {background: rgba(255, 94, 0, 1);
      background: -webkit-linear-gradient(top, rgba(250, 221, 0, 1) 0%, rgba(255, 94, 0, 1) 100%);
      background: linear-gradient(to bottom, rgba(250, 221, 0, 1) 0%, rgba(255, 94, 0, 1) 100%);
      border-color: rgba(0, 0, 0, 1);
      color: rgba(51, 51, 51, 1);
}
.btn-ral:active, .btn-ral:focus {background: rgba(255, 0, 0, 1);
      border-color: rgba(0, 0, 0, 1);
      color: rgba(0, 0, 0, 1);
}
.nopadding {
   padding: 0 !important;
}
/* Sticky footer styles
-------------------------------------------------- */
html {
  position: relative;
  min-height: 100%;
}
body {
  /* Margin bottom by footer height */
  margin-bottom: 100px;
}
.footer {
  position: absolute;
  bottom: 0;
  width: 100%;
  /* Set the fixed height of the footer here */
  height: 100px;
  background-color: #ffd100;
}
```

**B.4** – UCAS Cascading Style Sheet (RALfie Theme)

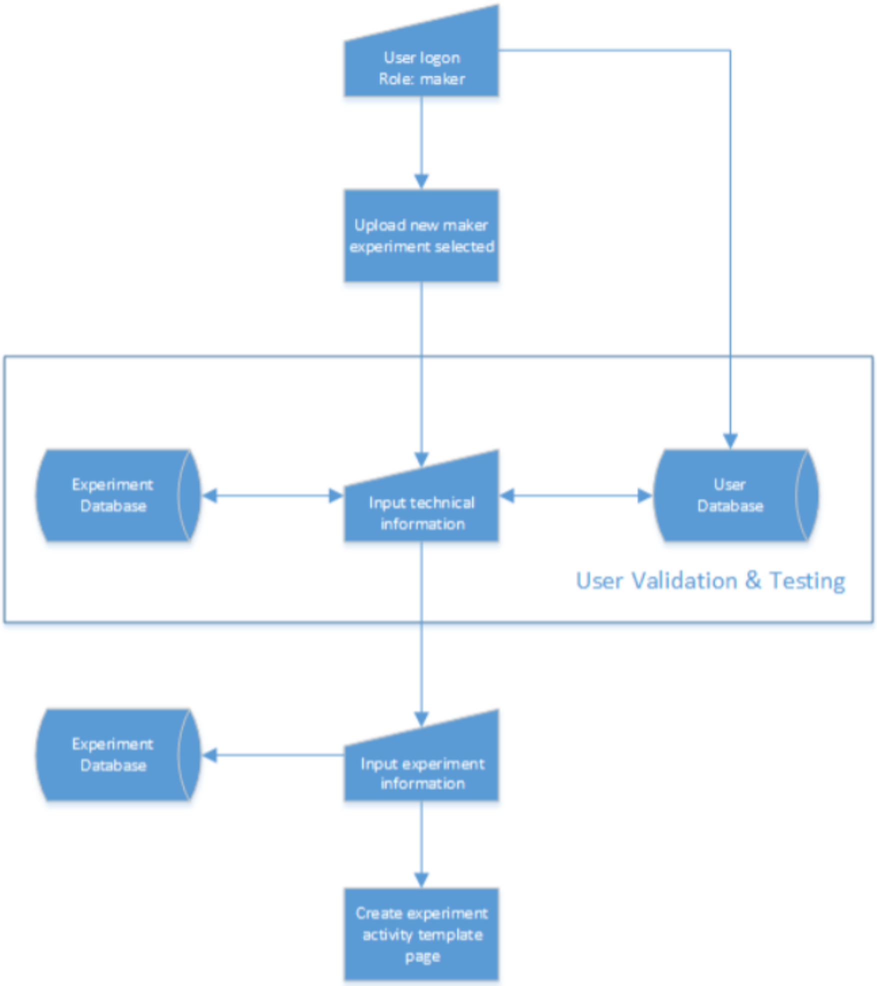
# Appendix C – Additional Workflow Diagrams



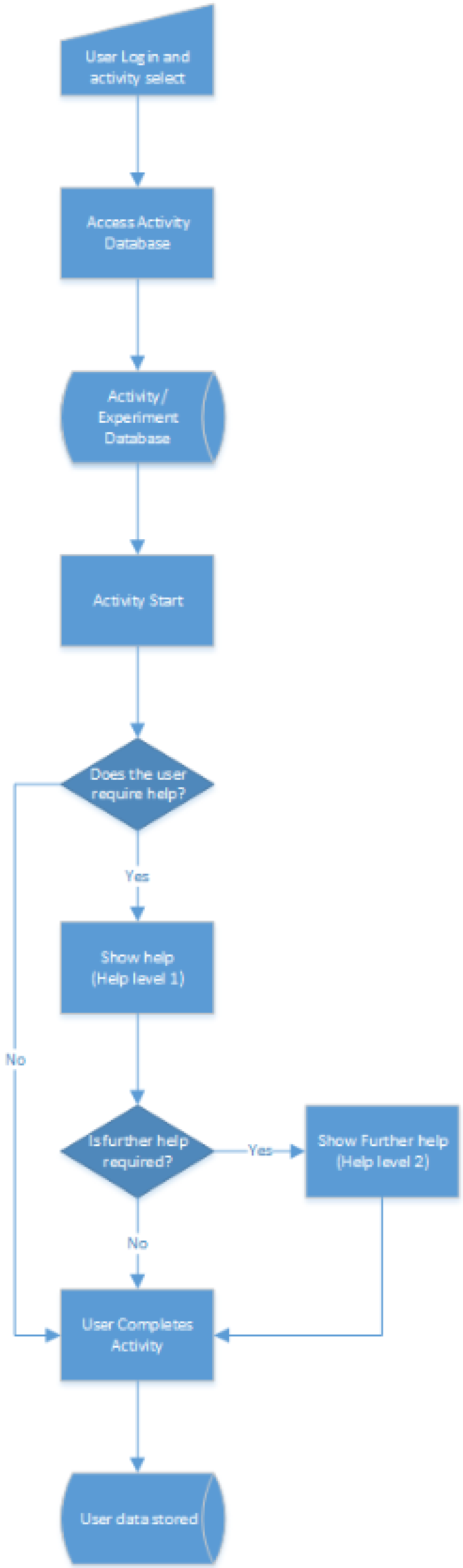

**C.1** – Workflow diagram for population of the Activity Homepage




**C.2** – General workflow of User Access and Activity Completion (1 cycle)




**C.3** – Proposed workflow for the Maker input process




**C.4** – Proposed Acitivty Access and Completion workflow

# Appendix D – Developmental Working and Design Documents

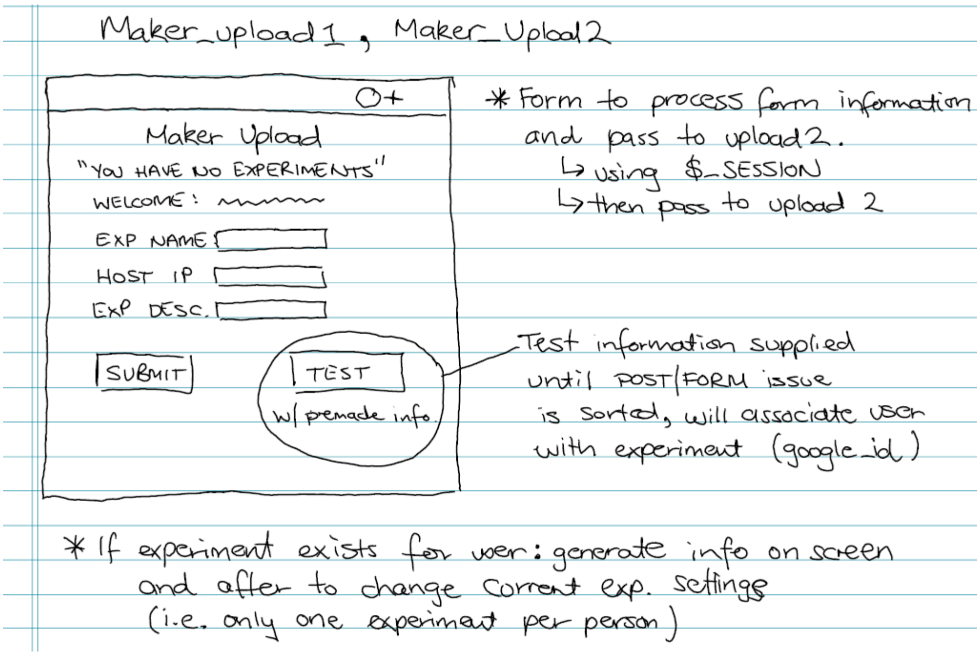
WORKING DOCUMENTS – **MAKER UPLOAD USER PROCESS**

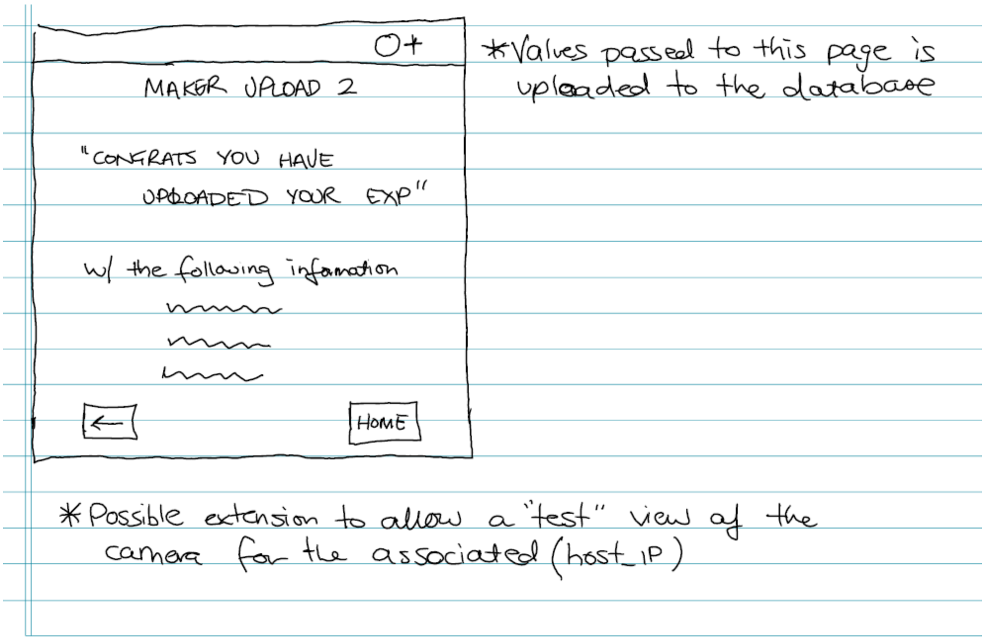
27/08/15 – Ryan B
Pages consists of **maker_upload.php** and **maker_upload2.php**.
**1. Maker Upload**
maker_upload.php consists of a form to record new experiment information, in regards to Experiment Name, Host I.P. and a short description of the experiment
a. Current Limitations - one user, of the maker role, may only have one experiment per Google ID **- further error handling needed to make sure no RALfie box numbers are doubled up on**.
b. Current Limitations - Form functions as of yet do not work, the link buttons associated with this page are to test the 'create' and 'update' sections using hard coded JS links.

- Page checks to see if experiment exists under this user name
- if so, passes along 'exp_exists=true' as well as the input information
- if not, passed along input information for creation of a new row in the experiments database
- Page redirects to maker_upload2.php

**2. Maker Upload 2**

Is passed the information, validates verifies before it writes data to the system
Displays completion message





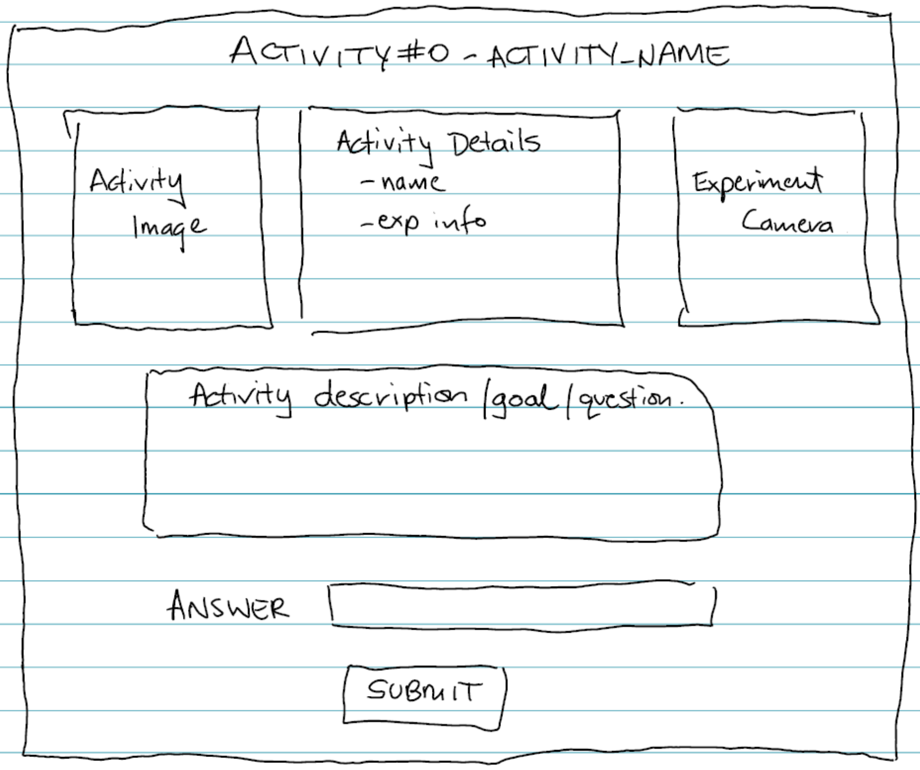

**D.1** – Maker upload process design documents

## USER ROLE 1 - Activity process

1. User logs in → selects ~~ex~~ activity for completion from list of verified activities

2. User is greeted by 'standard' marked up activity page passed through '?ID' OR to externally linked activity (html-maker also may be feasible)

3. User passes to completion page with either "true/false" on return info, either successful with rewards OR unsuccessful and "TRY AGAIN"




**D.2** – Activity Process Design (initial)

19/07/15 – Ryan B

**Pages added to repository**

activity_build_1 - Finds any exisiting activities recorded under the users ID, currently this is only for reference, all updating of activities will have to be done via the user information page. Button links to build_2 after selecting ‘add new activity’.

activity_build_2 - Questions user on whether the activity will be tied to an already verified real life experiment or is standalone. User can select no experiment, or from the list of current valid experiments.

activity_build_3 - User chooses method in which to build experiment, through the UCAS site by collecting information, or through an external link. HTML coding may also be a viable option.

activity_build_4B - This is the build page, asks for user input information to add it to the table of activities (starts off unverified and unseen by users). Dummy information currently being used to simulate form data.

activity_build_4L - **Not added until form functions are sorted out**

activity_build_5 - Collects information and writes to the database (or not).

Activity builder process

1. Process begins – user selects activity builder
   ↳ checks to see if user has activity (for update)
2. Select if Activity is connected to experiment or not connected to any (external/uploaded page)

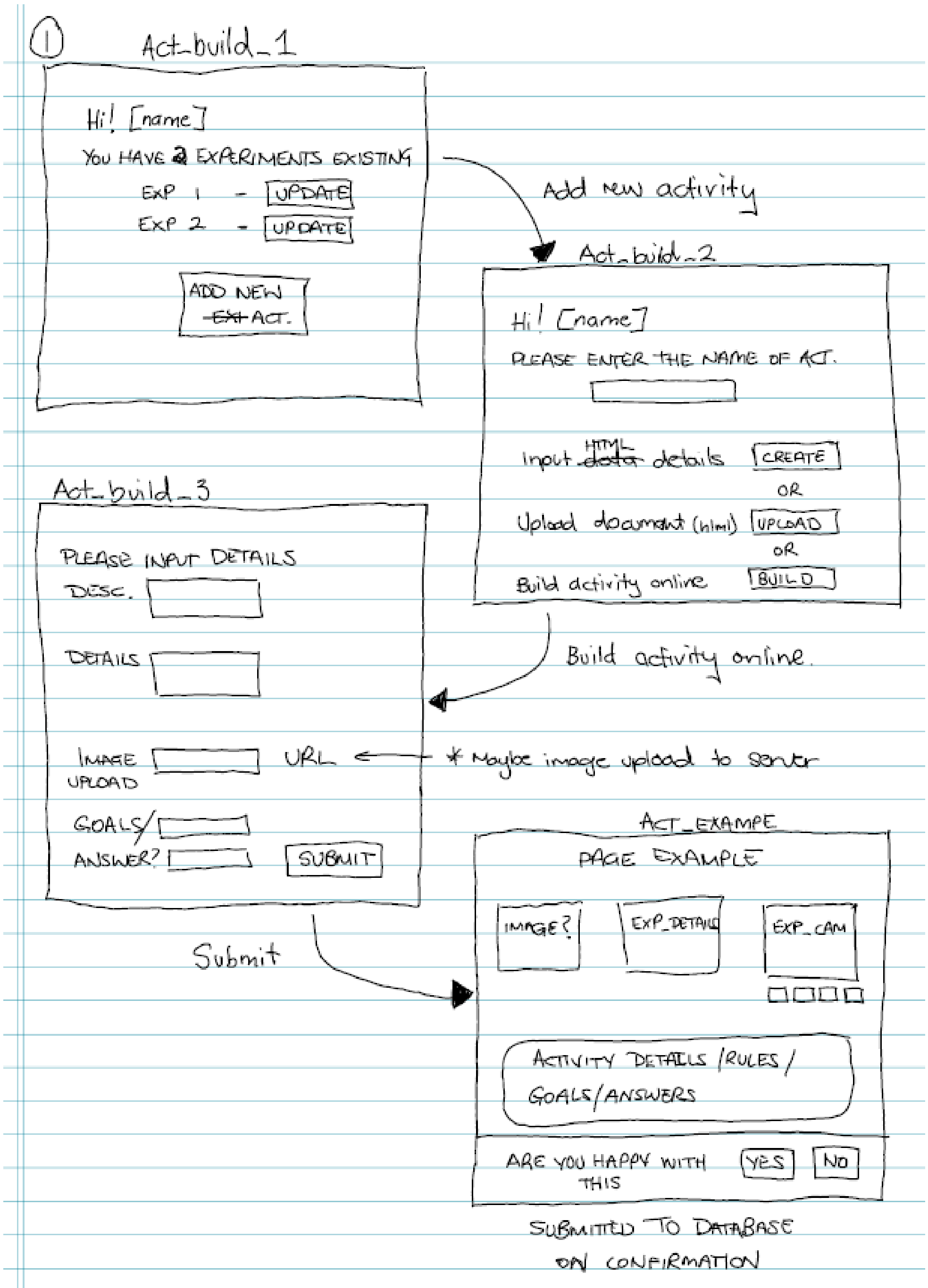
3. ~~a)~~ Choice to 'add page', 'add code', or 'build quest'

   a) add page – external URL page, added to database

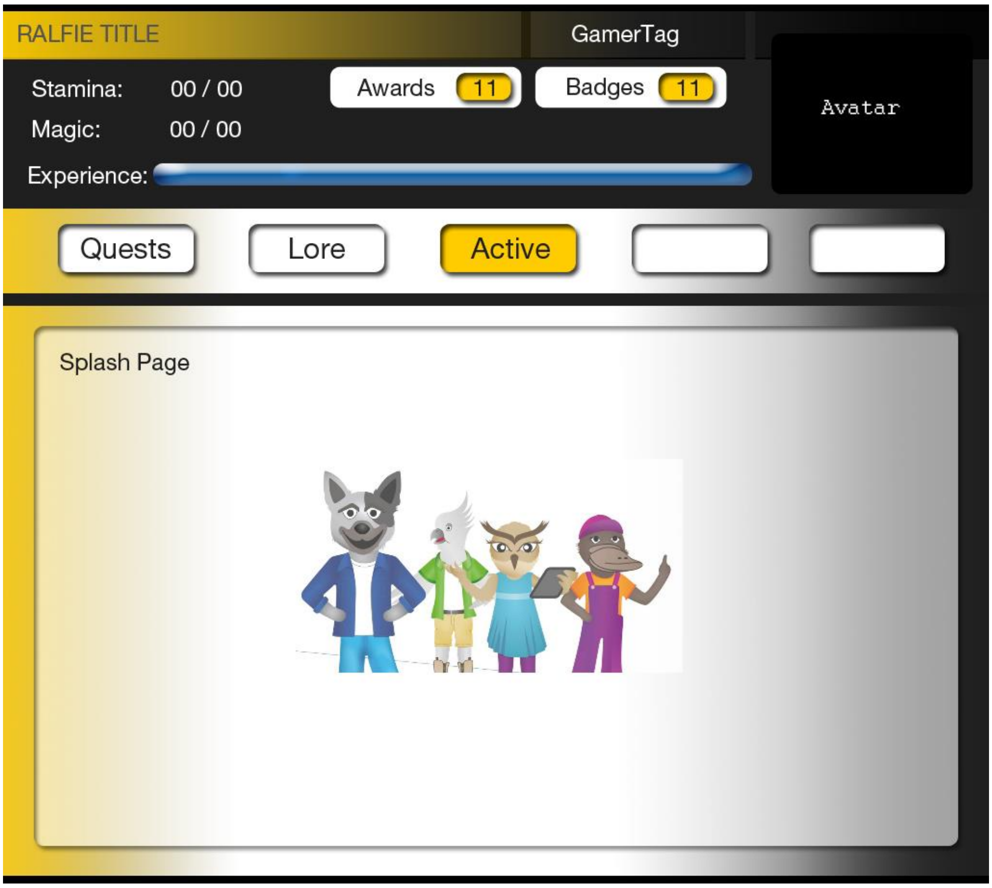
   b) add code – user implement html/php uploaded manually via textbox, or through user upload

   c) build quest – user input of information, saved in the database, upon access the page is built using this ~~3~~ experiment info

4. Information on user activity is saved under user. ID




**D.3** – Activity Builder Working and Design Documents




**D.4** – Initial Homepage Display Design