A Framework for User Controlled Knowledge Modelling of Mobile Information Delivery (About Wellness)

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A thesis submitted in fulfilment of the requirements for the degree of Bachelor of Information Technology (Hons) in the School of Information Technologies at The University of Sydney, Australia.

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November 7, 2012
Abstract

This thesis presents a framework for user controlled knowledge modelling of mobile information delivery. The background research used to inform the design of this framework is multi-disciplinary. Elements of research from wellness (with a focus on posture and physical activity), user modelling, personalisation, gamification and the psychology of learning have all been key considerations.

The framework aims to achieve three key goals: (1) to understand the role of gamification in providing an engaging learning environment, (2) provide an effective means of learning about potentially large information domains through mobile information delivery and (3) to model and quantify user knowledge. With regard to user knowledge, the research makes a clear distinction between perceived knowledge and actual knowledge and models these separately in order to conduct a comparative analysis.

The framework delivers information about posture and physical activity to participants in a qualitative study through the means of the smart phone app, Appollo. This app is an implementation of the general approach that is presented in the thesis as the framework design. The interface implements two novel design elements outlined in the general approach; the user driven avatar and the selection of confidence levels. The Avatar is informed by the user as they learn about concepts in the information domain. As a result, the user’s Avatar model defines their perceived knowledge.

Moreover, the user participates in quizzes that examines the content within the information domain that they have been studying. As they provide answers to questions they are informing the system about their actual knowledge. These two open user models, the avatar and user model, are then compared and contrasted by the system to provide instant progress in order to promote a greater self-awareness.

Compounding this notion of self-awareness is the inclusion of confidence levels in the design of the framework. The user is asked to provide their confidence throughout their interactions to reflect their faith in their feedback. This prompts the user to critically evaluate their progress while they are learning.

The qualitative study was conducted on 14 volunteer participants who took part in a Think-Aloud usability evaluation in addition to a questionnaire and interview. An analysis of the data collected was undertaken in order to evaluate the usability of the application and gain some insight into the framework’s ability to achieve its goals. The study concluded that the framework offers an engaging, challenging and ultimately fun environment that stimulates learning and proved to be effective in quantifying user knowledge.
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CHAPTER 1

Introduction

1.1 Thesis Statement

This framework for user controlled knowledge modelling delivers mobile information with the goal of tracking and quantifying a change or growth in knowledge of the subject area, wellness. Wellness is used as the domain of information to be tracked for the user by the framework. The domain is a large encompassing area of knowledge and as a result two elements of wellness: physical activity and posture have been used to focus the study. Physical activity and posture are inherently linked focal areas as good posture will enable more effective and less demanding physical activity.

The central thesis is focused on understanding whether certain techniques such as mobile information delivery, user modelling, personalisation and gamification can aid the development of user knowledge. Gamification offers implementation techniques from the video game development industry that could be effective in quantifying a change or growth in user knowledge, whilst providing a highly engaging means of learning; taking the pain out of learning. Moreover, mobile information delivery affords the user the ability to consume information in small, easily digestible pieces to aid the growth in their understanding. User modelling and personalisation is integral in capturing knowledge information in a scrutable model. This will be used to personalise the framework to suit the user in order to offer recommendations, suggestions and ultimately track all interactions with the framework.

The capture of sensitive personal information is an underpinning requirement to inform the framework about the development of the user’s knowledge throughout their interactions with it. The framework protects this sensitive information by allowing the user to control their data. This control removes any apprehension that users could have with providing personal information.
Chapter 1. Introduction

1.2 Motivation

Mobile and pervasive technologies have become increasingly integrated in the modern world. Mobile phones have become smart phones that are internet enabled over their cellular networks and they have been widely adopted. These devices offer the power and connectivity that affords a new class of application that is more aware and observant of explicit and implicit behaviors.

Walking down the street with a smart phone can inform this new class of application about where the user is, where they have been, where they are going and what activity they have had throughout their day. Moreover, this information can be aggregated over extended periods to create a life-long user model. Integrating with the vast number of key functions that a smart phone provides, such as text messaging, emailing, social plug-ins (Facebook, Twitter, etc.) and calling functionality could provide these applications with behavioral and emotional data. Analyzing this data affords the ability to quantify the changes in these data points.

However, the collection of this data is futile unless it is scrutable and can be used to query information about the user to be presented in some meaningful way. Visualising this data affords the user the ability to analyse changes, fluctuations and any trends in the data easily. A tool of this nature can be an effective means of self-monitoring. This can lead to self-diagnosis and a more self-aware existence that could lead to positive behavioral change.

Consider this scenario. Mary is a high school teacher trying to measure her student’s progress in her physical education class. Her course requires both a practical and theoretical understanding. The practical side of her course is conducted through two one-hour sessions a week, however the theoretical element of the course is completed through homework tasks that are often neglected by her students. Moreover, these homework assignments are hand-written. Mary would like to track and quantify the growth in her student’s theoretical understanding in a simplistic and automated fashion.

Mary begins her class by asking her students to download, install and register with Appollo on their smartphones or tablet devices. She then asks her students to sign up to her course. Mary has created this course by authoring the information package containing content that relates directly to the syllabus that she is teaching. The class has now subscribed to her course. Each student will now have a quantifiable model that will track the change in knowledge on an individual level.

Through the use of Appollo Mary can easily post new information and homework tasks to all of her students. In addition she will be able to monitor their progress on a daily basis. Moreover, when parent teacher interviews come around the scrutability of her students’ models will enable her to quickly produce a report for each student and an aggregated report for the growth of the class.

Mary’s students have left school and gone home. Bob is a conscientious student who is already on top of his work. Upon arriving home, he opened Appollo and completed the required readings and associated quizzes. Steven on the other hand is a less organized student who has forgotten to complete the homework that has been assigned. Throughout the afternoon, Appollo sends a message to each student that has not yet completed their work on their device of choice; reminding them to get to work. The students are called to engage with Appollo.
Appollo aims to take the pain out of learning. Ensuring user engagement is an important part in achieving this goal. Gamification can contribute to an increased level of engagement as it provides game-like functionality in a non-gaming environment. Each of Mary’s students will have an avatar. This avatar is designed to offer a challenging environment for the learners interacting with Appollo. The avatar is also used as a measure of performance. In essence, there are two types of knowledge; the knowledge we think we know and the knowledge we actually know. This lends itself to a clearly competitive and quantifiable proposition. As a result, the avatar models the information the student thinks they know.

Steven is a student that loves to play computer games and is a prolific social media microblogger. He spends most of his free time engaging in online social gaming and less of his time on his academic studies. Steven is connected with his class mates from Mary’s physical education course online. He notices that his friends from this course have been interacting with Appollo as they have posted their progress online. Toting, “The homework was so easy! Though I just realised that I am eating way too much sugar every day!” and “Yes! I beat my Avatar!”. Along with these messages, Appollo is publishing each student’s score.

Steven is intrigued and takes the time to engage with Appollo. Steven creates an avatar and connects the system with his social networking communities. He begins the homework task by reading the required pieces of information. As he reads, he provides feedback about his understanding of the information he has read; indicating whether he has understood it. Moreover, he is asked to provide a confidence level for the feedback he has provided. This information is informing and growing the knowledge of his avatar. Once he has completed the readings he starts the quiz against his avatar, competing for knowledge supremacy. At the end of the quiz, Steven is provided with a score based on his responses and confidence level. This score can be used to compare the student against their avatar and their cohort through the social community integration.

Integrating Appollo with gamified functionality achieves a level of engagement that is typically unparalleled in learning systems. Moreover, Appollo becomes a self-awareness tool for learning that provides the student with an open model that enables them to monitor their own progress. Moreover, the social integration provides the student the ability to compare their progress against their cohort.

This is quantifiable information that is highly useful. Mary and her students, down to the finest level of granularity, can see how far away they are from achieving their goals. Moreover, it will give Mary more control throughout the learning process to identify struggling students or areas of the syllabus that need further clarification. It is clear that quantifying the growth in understanding of the any learner offers significant benefits as a self-monitoring tool. However, when related to the domain wellness there is the potential for this tools to become a preventative health measure.

1.3 Risks & Challenges

The thesis statement outlines the underlying goal of the framework as understanding whether the application of certain design and implementation techniques can support users in mon-
itoring and controlling their growth or change in knowledge. As a result, the risks involved with this are human-centric.

User Studies

A component of the evaluation of the framework is in the usability aspects of its interface. This will require a group of users that are willing to provide feedback and their own personal information. This creates a challenge with regard to finding a group of users who are willing to offer their time. Further to this, securing the personal information collected from these users will be a challenge, as they will need to feel comfortable with sharing sensitive data.

Framework Design

Designing a framework carries with it the expectation that it will be inherently useful outside of its original domain. This thesis looks at the framework within the domain of wellness. However, the framework should be aiming to achieve knowledge management of any domain independent information. As a result, there is a significant challenge to be overcome in the design of the framework.

Scrutability

Modelling the user with the intent of the resulting representation begin scrutable poses a clear design challenge. Scrutability can be hard to achieve without providing a means for users to access and explicitly change the data stored about them. Each model of the user must be owned and obtainable by the user.

User Modelling

Knowledge management requires a means of tracking, visualising and understanding the change or growth of the user’s knowledge over a certain time period. The model that defines the user must be able to store this data in some meaningful way. This is a design challenge that can be overcome by identifying a means of quantifying this data. Tools and techniques employed in gamified systems offer the ability to achieve this quantification and have informed the design of the user model.

Interdisciplinary Research

This thesis and framework integrates many areas of research. Each specialised area has a clear link to the goal of the thesis, though they are in some cases from entirely different fields. The challenge for the framework in this regard is developing clear and logical links between wellness, mobile information delivery, personalisation and user modelling and gamification while maintain a cohesion that supports the central argument.

1.4 Research Contribution

Understanding the relationship between the areas of research outlined in this thesis is the intended contribution of this research. Exploring the role of gamification in the development of a user controlled knowledge modelling framework to discover how to quantify the growth and change in the user’s knowledge about a domain of information. Moreover, the
delivery platform for this information is mobile. The research contributes a framework that concludes whether delivery of mobile information provides an effective platform for easy, simple and concisely digestible amounts of information and whether that has facilitated user comprehension. Moreover, the framework provides a foundation of design to enable the tracking and modelling of knowledge for any information domain. This should inform future work and contribute to the lives of people who wish to quantify their knowledge.

1.5 Thesis Structure

Chapter 2 discusses and outlines the previous research in the multi-disciplinary fields of research relating to this study and outlines gamified systems that are used to inform the design of the framework. Chapter 3 will outline in detail the design of the framework with respect to its user modelling, personalisation and gamification elements. Chapter 4 describes the implementation of the framework in the form of the Appollo app with a focus on the user’s perspective of the software. Moreover, usability evaluations have been undertaken in the form of Think-Aloud studies, questionnaires and interviews and the results are outlined and analysed in Chapter 5.

1.6 Key Terms and Themes

- User Controlled: The user of the framework will be in complete control of the information they provide. Users will own information provided by themselves and will have the control to alter that at their will.

- Knowledge Management: Tracking and controlling the known sources of information that have been digested with the intent of understanding and knowing them.

- Gamification: A common summary term for the rapid growth of consumer software that takes design cues and inspiration from video games (Deterding, Sicart, Nacke, O’Hara, and Dixon, 2011b).

- User Modelling: A user model can be used to describe information about people. Typically this information is in the form of preference or personal information that is useful in defining a user or a group of users with common characteristics (Rich, 1983).

- Personalisation: The ability for a system to adjust its user interface to suit the preferences of either an individual user or a group of users (Chellappa and Sin, 2005). Personalisation can be driven by a user model as the source of knowledge about a user.
CHAPTER 2

Related Work

This chapter outlines the related wellness, gamification, personalisation, user modelling, gamification and systems that can be used to inform the design of the framework. Wellness, with a focus on physical activity and posture, is the content domain to be modelled by the framework. The health issues created by being physically inactive and having poor posture are discussed and some solutions from previous work are outlined.

Moreover, gamification is discussed as a possible solution to creating an engaging learning environment and quantifying the growth in user knowledge. Gamified systems have been able to utilize game development techniques to stimulate user activity and engagement in non-gaming contexts. As a result, these principles and results gathered by related gamified systems can be instructive in the creation of gamification functionality in the framework.

User controlled knowledge modelling has a few key components that relate to the areas of research in e-Learning, personalisation and user modelling. For users to be able to manage their knowledge, they need to store data about their interactions with the framework. Personalisation, driven by user modelling, has been explored as a method to achieve this. Further to this, learning is a component of knowledge modelling. Managing a user’s knowledge implies that there will be a change in the subset of information that they know. Due to this, e-Learning systems, in particular m-Learning systems, have been discussed.

The areas of research and related systems discussed in this chapter aim to provide a foundation of knowledge to inform the design of the framework.

2.1 Wellness

Wellness can be defined as a proactive approach to the prevention of disease and is guided by a desire to pursue a more rewarding lifestyle (Ardell, 1979). Disease prevention strategies have often been intertwined with regular physical activity as a prevention tool (Southern, Loftin, Suskind, Udall, and Blecker, 1999). Moreover, good posture as a comple-
mentary element of wellness to physical activity can be effective in preventing injury and ensuring comfort while undertaking physical activity (Karhu, Kansi, and Kuorinka, 1977). Appollo will be targeting posture and physical activity given their association and direct affect on an individual’s wellness.

2.1.1 Posture

Posture is an important factor in the maintenance of good health. People with poor posture often look unwell and are more likely to portray poor self image. Lower-back pain and an increase in the incidence of injuries due to the overuse of particular muscles are all caused by poor posture (Watson and C, 2000).

Improving posture has been a priority for people hoping to decrease discomfort and avoid injuries and has been tackled by a number of systems. Karhu et al. (1977) created the Ovako Working Posture Analysing System (OWAS) that enabled engineers to quantify the frequency and time spent in particular postural positions. The system aimed at improving working postures especially in physically demanding vocations. The system resulted in improvements to the comfort in individual jobs and has reconstructed some production lines.

Similar systematic approaches have stemmed from this research and has displayed the economic benefits of effective ergonomics evaluation. Klippert, Gudehus, and Zick (2012) evaluated a system that aimed to automate the process of ergonomics evaluation on an assembly line. The system promised a means of simplifying the arduous and costly task. The system’s evaluations were benchmarked against a physical study undertaken using the OWAS system. The results of this study showed that the system could produce reliable evaluations and could be used as a suitable means for evaluation in the early design phase of a working environment. As a result, an ergonomic environment will achieve a comfortable working environment and higher productivity (Vink, Koningsveld, and Molenbroek, 2006).

Developments in sensor technology have enabled the kinematic analysis of behavior and have assisted in the monitoring of posture. Multichannel accelerometry (the use of multisite calibrated sensors) has been effective in determining posture and the observations and patterns of movement can be used to provide an understanding of behaviors, symptoms and physiological changes (Foerster and Fahrenberg, 2000). Context-aware mobile devices, that are often equipped with accelerometer sensors, are becoming increasingly prominent in monitoring and logging its user’s environment and behavior (Martín, Bernardos, Iglesias, and Casar, 2012). These devices could be the appropriate means to collect this rich postural data.

2.1.2 Physical Activity

Physical activity is often perceived as a basic tenant for the maintenance of a healthy lifestyle. Moreover, it is considered that physically active people are healthier than their less active counterparts (Haskell, Montoye, and Orenstein, 1985). Such claims are substantiated by scientific evidence that links regular physical activity to physical and mental health benefits (RR, M, SN, and et al, 1995). A benefit that creates the belief that physically fit people are healthier is the reduced risk of death as a result of regular physical activity. SN, HW, III, RS, Jr, DG, KH, and LW, 1989, concluded that there is a significant increase in risk rate for all-cause mortality in individuals of the least-fit quartile in both men and women in their study of a sample of white-collar professionals.
2.1. Wellness

Physical inactivity, on the other hand, has recently been labelled as a pandemic and should become a public health priority. It is suggested that the prevalence, magnitude of risk and evidence for prevention and control are critical (3rd, Craig, Lambert, Inoue, Alkandari, Leetongin, and Kahlmeier, 2012). Fortunately, advice provided to patients by their physicians and health professionals is now reflecting a greater emphasis on the need for physical activity. This has grown from 22.6% in 2000 to 32.4% in 2010 (Barnes and Schoenborn, 2012). As a result, stimulating physical activity can be highly effective in helping combat the pandemic that is physical inactivity.

2.1.3 Wellness Management

There is a clear relationship between posture and physical activity. Good posture can dictate how comfortable an individual will be when being physically active. Moreover, the importance of understanding this relationship will be paramount to the success of a preventative wellness strategy. As a result, management of wellness knowledge could be an effective means of increasing an individual’s level of physical and mental fitness (Omizo, Omizo, and D’anrea, 1992). Moreover, the management of activity logging could be effective in increasing the frequency and length of time that an individual is physically active.

Knowledge Management

Wellness management is a preventative health measure and is dependent on the individual’s daily management. This could be defined as self-management as the individual’s development is entirely driven by their own drive and enthusiasm. Self-management is encapsulated by the following five skills: problem solving, decision making, resource utilization, forming of patient/health care practitioner partnership and taking action (Lorig and Holman, 2003).

Decision making is a skill of these five that is important in ensuring the self-management of wellness. Daily decisions with regard to physical activity, such as ‘have I exercised enough today?’, can be easily resolved with the support of a self-management system. Two key issues are identifiable with the previous question: (1) “how much exercise is enough per day?”, (2) “how much exercise have I completed already today?” (Lorig and Holman, 2003). (1) can be resolved through effective knowledge management: if the user’s knowledge is being modelled the information that they are missing to answer the question can be presented. (2) can be resolved by an effective and up-to-date activity logging system.

Activity Logging

Promoting a regularity in physical activity is an important factor in improving an individual’s overall wellness. This regularity has proven to provide the benefits of an overall increase in the quality of life (Warburton, Nicol, and Bredin, 2006). However, many people find a challenge in increasing the amount of daily exercise they can undertake (Consolvo, Everitt, Smith, and Landay, 2006).

The act of manually logging an individual’s physical activity has proven to positively impact the levels of physical activity. The study conducted by (Speck, 2001), considers the effect of daily activity logging on the average number of daily steps taken by a group of individuals. The study used pedometers to measure the number of steps and monitored two groups; the intervention and control groups. The results of this study displayed a
Chapter 2. Related Work

significant increase in the number of steps taken by the intervention group and concluded that daily activity logging does increase physical activity.

2.2 Gamification

Gamification is a common summary term for the rapid growth of consumer software that takes design cues and inspiration from video games. The gamification movement is responsible for game design and interaction elements being used in non-game contexts (Deterding et al., 2011b). The definition of gamification, since its creation, has been subjective and scrutinized by academics. However, the underlying principle focuses on the benefit offered to clients and end-users that is the ability for game mechanics to solve problems and engage users in a profound way (Deterding, Dixon, Khaled, and Nacke, 2011a).

Achieving a gamified system requires the design of the system to be closely linked to the design principles of commercially successful games. Programs that abide by the solid game design principles are referred to as serious games. These games have evolved into systems that promote deep, persistent engagement as well as learning (Johnson, Vilhjalmsson, and Marsella, 2005). M. 2002, asserts that the role of games in learning is to alleviate the pain from the process. This associated pain has been considered a rite of passage in learning. However, gamification and the use of serious games provides the potential for a revolution in learning to create a more learner-centered, engaging and fun method of delivery.

Similarly, the application of gamification to health and wellness affords the creation of tools that can be effective for preventative health. McCallum 2012, asserts that computer games and personal health share the ability to shift the focus of health care from the expert trying to diagnose symptoms to the individual managing their own health. “Flow” is a gamification term used to describe the deep persistent engagement that users experience when gaming (McCallum, 2012). Flow matches the user interactions with the system and the state of the individual providing a symmetry between the two. The affords an opportunity for gamified health systems to create a symmetry between the individuals and personal health goals.

The Appollo framework framework aims to support its users in their pursuit of better understanding how to improve their wellness. Gamification is explored as a means of capturing the user’s knowledge throughout their interaction with the system. The benefits of gamification can be directly applied to the measures of wellness explored in this thesis: posture and physical activity. These benefits will promote engagement and enable Appollo to measure the potential proliferation in their knowledge and positive behavior.

2.2.1 Gamified Systems

The goals and benefits of gamification have been implemented in a number of systems that aim to provide an engaging way of achieving their goals. Gamification is not limited in its ability to offer this engaging environment as there have been a number of systems that leverage its benefits to achieve a greater level of physical activity, testing the user’s knowledge or tracking and managing the behaviors of its users. Some examples of gamification in non-gaming contexts are discussed in the following system case studies.
2.2. Gamification

Brain Age

Brain Age is a training system that positions itself as a healthy exercise program to maintain good brain function. The application is built for the Nintendo DS gaming system and offers fun and challenging activities such as word puzzles and memory games. The consumer based system has reached a large market and has been generally well adopted after achieving a milestone of 4 million copies sold in the US, UK and Japan in 2006 (Surette, 2006). After completing a number of brain exercises the gamified system will provide the user with a value for the age of their brain.

The effectiveness of this gamified training system was evaluated by Nouchi, Taki, Takeuchi, Hashizume, Akitsuki, Shigemune, Sekiguchi, Kotozaki, Tsukiura, Yomogida, and Kawashima, 2012. This study aimed to show whether the brain training game was able to improve the cognitive function of the participants in the study. The participants were elderly volunteers that were allocated to one of two game groups; playing Brain Age or Tetris. The study tests the participants cognitive functions in four categories: global cognitive status, executive functions, attention and processing speed. These tests were undertaken before and after the use of the participant’s allocated game. The evaluations concluded that there was a clear cognitive benefit for the users that participated in a regular use of the application.

2.2.2 System Case Study: Fish’n’Steps

Lin, Mamykina, Lindtner, Delajoux, and Strub, 2006 created the Fish’n’Steps system to combat the negative effects of a sedentary lifestyle. This social computer game combines elements of social networking and gamification to promote physical activity. The authors assert that behavioral change has been traditionally achieved by a trained specialist in either individual or group settings; through the means of goal setting, self-assessment or monitoring of achieved progress.

These approaches can be directly targeted by computerised systems by providing real time or “just in time” data to aid in decision making and monitoring. The Fish’n’Steps system utilises a pedometer to monitor a cumulative step count for each day. This data is used to contribute to the individual’s goals and their team’s goals. The individual was able to manage and track their increase or change in number of steps on a daily level of granularity. Moreover, the user is able to see their progress with respect to their team and other teams using the system. The goal for this system is to create
Chapter 2. Related Work

an engaging and competitive environment for its users to feel rewarded for the behavioral change they exhibit.

Moreover, the competitive nature of this gamified system stimulates a further level of engagement through social interaction. The system created a network of like-minded individuals, competing against each other. This provides the benefits of integrating social and family participation in the process of behavioral change; a traditional technique that benefits from a gamified physical activity system.

2.3 Personalisation & User Modelling

Personalisation can be defined as the ability for a system to proactively adapt and modify its interface to suit the user. The benefits that personalisation offers are more efficient and relevant information retrieval and contextual help that supports user interaction. This personalised support has proven to improve the effectiveness of user interfaces; resulting in more usable systems (Fink and Kobsa 2000). Personalisation data are captured through either an explicit or implicit means and are stored in a user model. The Appollo framework uses personalisation to model the user in order to encapsulate the user’s understanding of the content presented to them.

The rules or heuristics that are used to drive personalised interfaces come in the form of models that can take on a number of different forms. An example of a personalisation framework can be found in the Object Oriented Hypermedia Method. This method uses an XML based representation of two models: the reference model (storing user activity data) and the user model (storing user preferences required for personalisation). The interface in this framework is a web application and is viewed as a formation of a stable and variable part. The stable part of the application refers to the application code as it is user independent. The variable part(s) are the models expressed in XML that are used at run-time to modify the user interface after being interpreted (Garrigos, Gomez, and Cacherd 2003).

Appollo will be built on this underlying principle. An embedded user model, expressed in an arbitrary markup language, such as XML or JSON, will be used at run-time to personalise the interface. This personalisation will determine how the system behaves and will drive the gamification utilised by the framework.

2.3.1 User Modelling & Open Learner Models

A user model is a knowledge source in a system which contains explicit assumptions on all aspects of the user that may be relevant to the system and is separable from the rest of the system’s knowledge (Wahlster and Kobsa 1989). The model is formed by obtaining a set of specific pieces of information about the user that the system is seeking. Moreover, the definition of this model when represented in a computer system can be understood as either a canonical model or an individual model. Canonical models, by their very nature, are standard models of users, whereas a model of an individual user is created as a result of the user either implicitly or explicitly providing information about their needs and goals (Rich, 1979).

There are many ways of representing a user model; a few key methods are discussed here. The first technique to consider is a Bayesian Network. A Bayesian Network can be represented as directed acyclic graph where nodes are random variables and edges are probabilistic correlations between them. The Bayesian Network aims to understand the relationships between the goals and needs of users (Horvitz, Breese, Heckerman, Hovel)
2.3. Personalisation & User Modelling

User stereotypes can be employed to represent a user model by collecting a few pieces of information and making an association with the knowledge stored about groups of users to stereotype the user. These stereotypes represent a cluster of common characteristics and can be used to very quickly model the user (Rich, 1979).

Personis, a server-side user modelling framework, provides another method for representing a user model. The framework creates a unique user model, identified by a name, for client systems to inform and query. The model is a hierarchical structure of contexts and components that accumulate pieces of evidence to describe user preferences (Kay, Kummerfeld, and Lauder, 2006).

To ensure that the Appollo framework allows user controlled knowledge modelling the user model that it creates must be scrutatable. Personis offers this desired level of scrutatability as it uses a number of generic scrutiny interfaces to interact with the its User Model server. These interfaces can be in the form of a custom application or, with relation to this thesis, the Appollo framework.

These interfaces are offered the ability to Ask or Tell a specific model to gather information or inform some evidence, respectively. An ask request will result in a dictionary of values that represent the query and have been provided as evidence in a tell from a generic scrutatable interface that is authenticated with the model (Kay et al., 2006).

Acquiring a User Model

Building a user model requires information to be captured either explicitly or implicitly. Explicit information is highly simplistic as it is obtained directly from the user by asking a series of questions that might categorise them; such as demographic information and personal interests (Schiaffino and Amandi, 2009).

In order for the Appollo framework to utilise a user model the system must explicitly or implicitly capture data about the user. Using a unique model for personalisation will create a period of time in which the system cannot adapt its interface due to an undefined model; referred to as a cold-start. In order to reduce the impact of this, the user could be stereotyped in order to build a quick and generalised model. Explicit data capture methods could be used to capture enough data about the user to make matching them to a stereotype possible (Rich, 1979).

Another method of user model acquisition is displayed by the Twitter-Based User Modelling Service. This service uses a simple inference engine to create logical user profiles from the messages the user has posted on Twitter. Twitter is a popular micro-blogging website that allows users to ‘tweet’ about a diverse array of topics, all of which interest them. Crawling through Twitter provides raw data for the creation of a user model that specifies how much a user is interested in a certain topic and is expressed as a metadata model in the Resource Description Framework (RDF). This is achieved by collecting tweets using the tweet crawler, categorising the topic of the tweet, linking the tweet to related news (where possible) and finally applying a user modeling strategy (Tao, Abel, Gao, and Houben, 2012). The modeling strategies differ in the types of profile information, weighting schemes, enrichments (linking to news items) and temporal constraints (such as specific time periods). Despite the differing strategies the underling user model definition remains unchanged; a set of weighted concepts with respect to the user’s interests. These user profiles are made available via a web service and could be used similarly to stereotypes, or aggregated to create a stereotypes to reduce the impact of the cold-start.

Applying a Bayesian Network to Appollo could provide the implicit acquisition of...
Chapter 2. Related Work

A user model. The network could be applied to show the relationship between a user’s perceived and actual knowledge. For example, the variable (node) in the network could be defined as an article of some arbitrary content domain. Moreover, an edge (relationship) could then be made between the user when they nominate that they have understood an article. Furthermore, a second relationship could be implicitly made by the framework once it has identified that the user does in-fact understand the content of the article. As a result, all networks that are cyclical represent knowledge that the user has proven to know (Schiaffino and Amandi, 2009).

Utilising both the explicit and implicit methods of user model creation could be most effective for the Appollo framework. Explicit techniques could be employed to capture the user’s self-perceived knowledge. Implicit methods, on the other hand, could be used to capture the user’s actual knowledge by coupling it with an element of gamification.

Furtherto this, in order to reduce the effect of a cold-start techniques such as stereotyping user models and services such as the Twitter-Based User Modeling Service could be an effective integration to gain some initial, explicit knowledge.

2.3.2 Open Learner Models

The process of learning is supported by the student’s ability to assess their knowledge in order to identify what elements they need to study. In essence, the ability for a student to self-assess their progress is important in developing their skills. The use of open learner models in a learning system supports this self-assessment. Mitrovic and Martin (2007) studies the effect of the open student model with the SQL-Tutorsystem. The tutoring system aims to provide an effective tool that facilitates student understanding of the common database query language, SQL. The development of this system has been created as a result of the need for greater user feedback in Artificial Intelligence in Education systems that had previously been used. These knowledge-based teaching systems typically do not inform the students that a model has been created for them and that their data is being collected.

The primary goal of an open learner model is to provide information about the model that the learner has created through their interactions with the system. This accessibility to the user model promotes educational benefits such as encouraging learner reflection and metacognition (Bull and Kay, 2007). The open nature of these models enables the user to quickly identify gaps in their knowledge or elements of the content that they have struggled with.

There are many ways in which the learner model can be presented to the student and is highly dependent on the underlying implementation of the user model and the audience that will be receiving the information. For example, presenting a learner model to young children would need to be in a very simplistic format, such as a knowledge level represented as a range of coloured smiling faces (Bull and Kay, 2007). Conversely, SQL-Tutor’s target demographic was university students studying a technical area of information. As result, the open learner model presented to them could be more complex and provide further detail; six skillometers showing the student in terms of the six clauses of the SELECT statement. These skillometers represent a progress bar for the student in the given area of knowledge (Mitrovic and Martini, 2006). Analysing these progress bars affords the user the opportunity to assess which of the six clauses in the SELECT statement they are struggling with.
Overlay Models

The SQL-Tutor open learner model is created as a simple overlay model that maps the constraints of the user model to the learner’s progress (Mitrovic and Martin, 2006). The overlay model is a technique for describing a student’s problem solving skills that was defined by Carr and Goldstein, 1977. When modeling the user with an overlay approach the system considers the user as some deviation of the expert model. The expert model would simply define a model of some user that would have “perfect” knowledge. Deviating from this expert model would define another user or learner in the system that has some derivative of this perfect understanding; defined by their interactions with the system.

Defining this deviation from the expert model can be obtained by outlining a rule system that utilises multiple sources of evidence (Carr and Goldstein, 1977). These types of evidence can be in one of the following forms: structural and explicit. Structural evidence provides clues into the student’s knowledge from an analysis of the intrinsic structure of the skills to be conveyed. In essence, this is a network that links the skills in the syllabus in terms of their complexity and dependency. Explicit evidence can be obtained by observing the responses to the questions that the system asks of the learner.

The overlay model has clear applications to a knowledge modelling framework. The explicit capture of evidence to support the modelling of user knowledge can be directly applicable to the creation of the user model in the Appollo framework. Moreover, the use of an expert user model to query the responses provided by the user could prove to be an effective means of creating a self-awareness tool.

2.4 Learner Confidence

When consuming information learners often have a feeling of knowledge as they reflect on the information they are learning about. Levels of confidence are an important component of this feeling of knowledge as it reflects the degree of certainty the learner has about their own performance while completing tasks relating to the area of knowledge they are studying (Allwood and Granhag, 1999).

This measure of confidence in the learners own knowledge offers the ability for self-regulated learning. Prompting the learner to provide their confidence level when answering questions or making decisions within a system provokes an immediate reflection on their current performance. This can be useful in characterising a learner as either a over or under confident person.

This characterisation of confidence, either under or over, can be damaging to the learning process. Under-confidence can induce anxiety and negative behaviors such as procrastination or general negativity that can lead to a lack in productivity throughout the learning process (Want and Kleitman, 2006). Becoming self-aware could offer benefits to the learner and inform their feeling of knowledge. Being constantly asked by a system to provide a confidence level and assess their progress could potentially force the user into being aware of how confident they truly are with the content they are consuming or being tested on. Moreover, capturing confidence levels can offer a definition of the learner’s perceived progress and their actual progress (with regard to their knowledge of the information domain).
2.5 e-Learning & Information Delivery

The Appollo framework focuses on quantifying the difference between a user’s perceived and actual knowledge about a subject area. To achieve this, the system must aim to teach, instruct and be didactic in the way it presents information about the subject area; focusing on wellness. There are many ways of delivering information that promotes learning, such as e-learning systems, adaptive education systems and recommender systems.

E-Learning Systems

Since 2003, the ‘e-Learning revolution,’ has created a class of technologies that have provided a remote means of delivering training and information (Welsh, Wanberg, Brown, and Simmering, 2003). The continual growth in Internet usage and capabilities has enabled the delivery of large quantities of information to computers and mobile devices; contributing to the growth in e-Learning. Mobile e-Learning has followed this growth in remote learning and has enabled mobile users to find information while in the field (Georgiev, Georgieva, and Smrikarov, 2004).

Mobile e-Learning or m-Learning has been defined as “any service or facility that supplies a learner with general electronic information... that aids in the acquisition of knowledge regardless of location and time” (Lehner and Nösekabel, 2002). Appollo can be defined in the same manner as it will deliver succinct wellness information with the goal of informing the user about the key aspects of good posture and physical activity.

Recommender Systems

A recommender system is a form of personalised information delivery system. The goal of a recommender system is to represent user preferences with the aim of recommending items for examination. Typical applications of recommender systems have been in ecommerce and information access systems though recommendations could be an effective addition to Appollo as it simplifies the access of relevant information for each user (Burke, 2007).

The implementation of a recommender system requires background data, defined as information obtained before the recommender system has begun (e.g. item meta-data in an ecommerce system), and user preference data provided to the system as input into a recommendation algorithm which utilises one of a number of well established strategies (Adomavicius and Tuzhilin, 2005). This brief study of recommender systems deals specifically with content-based recommendations that make associations and subsequent recommendations based on a user’s previous interactions with the system. Content-based recommendation is the most simplistic of the recommendation technologies as it is limited by the number of associations it can make for recommendations and suffers from a cold-start due to a need for previous interactions (Burke, 2007).

The use of a content-based recommender system could be effective in modelling the perceived knowledge of a user. The user will inform the model by indicating whether they have understood the content presented by the framework. Given that content-based recommendations are estimated based on the utilities assigned by the user to items that are similar (Adomavicius and Tuzhilin, 2005), the system could model items as articles and the utilities as the user’s feedback (e.g. ‘I Understand’ or ‘I need more information’). For example, assume a user has read three articles about wellness, this user has indicated that they have understood two of these and has needed more information on an article titled ‘How to Improve Your Posture’. The recommender system will be able to use this model of the user to present more information related to improving your posture.
2.6 Summary

Adaptive Education Systems

An alternative approach to generation personalised information is through the implementation of an user-adaptive information systems which have one distinguishing feature a user model that is used to create the adaptation effect; interface personalisation. A subset of these adaptive systems are Adaptive education systems (AES) and are used in education to provide the most relevant pieces of information for students. The information retrieval in an AES system is based on a user model that captures the user’s knowledge, interests, goals and tasks, background and individual traits (Brusilovsky and Millan, 2007).

Understanding the user’s knowledge of the subject area in an AES system appears paramount importance as it is the most pervasively modelled user feature and is often used for both adaptive navigations support and adaptive presentation. This feature of a user continues to evolve throughout the life of the system as the user’s knowledge can either increase or decrease and the AES must reflect these changes. An approach to modelling this is a scalar representation, either quantitative scale (e.g. a 0-5 rating) or a qualitative scale. This model is then used to support adaptive presentation, a technique that could be employed to enable the Appollo framework to generate personalised. After categorising the user’s knowledge of a certain domain the AES can provide ranked results to searches or can retrieve more relevant information when searching and making recommendations (Brusilovsky and Millan, 2007).

The fundamental difference between recommender systems and adaptive education systems at a user level, is in the presentation of the information retrieved. A recommender system will retrieve a small and highly personalised subset of the items that match a search. However, when searching in an AES system, the search results are presented in a manner that highlights the user’s attention to items that may be of the most use (as a result of personalisation) and defers their attention to less personalised results.

2.6 Summary

It is clear that the health issues people are susceptible to with regard to physical activity and posture are created due to a lack of knowledge. Providing a tool to increase the knowledge and promote physical activity and engagement with information about posture could be effective in improving people’s wellness.

Gamified systems have proven to offer a high level of engagement. Leveraging this engagement will assist the Appollo framework in capturing user data. The data collected will be a snapshot of the user’s wellness knowledge, stored in a user model. This model will afford the user the ability to quantify their improvement in wellness knowledge. In order to have this user data `user controlled’ the model that it is stored it must be scutable.
Chapter 2. Related Work
Design of the Framework

The creation of the Appollo Framework is based on the claim that supporting long term learning of potentially large collections of snippets of knowledge in a domain such as health would be beneficial in the growth of user knowledge.

The Appollo Framework creates an architecture for user controlled knowledge modelling requiring a number of elements to be modelled. The elements that are modelled by the architecture are the user, the information domain (information about wellness) and the user’s knowledge that is validated by the gamification functionality. A key design decision in the integration of gamification to the framework afforded the introduction of a user driven avatar.

The goal of this architecture is primarily to provide a simple, yet effective way of quantifying the user’s change and growth in knowledge. The knowledge modelled by the framework in this thesis is about wellness. However, the framework is not exclusive. An additional goal in the design of Appollo is that the information domain presented to the user can be easily extended. Provided that the information is modelled in a manner that complies to the framework’s underlying structure.

As a result of this, the framework creates a tool that offers an interface for user controlled knowledge management of any and all of their knowledge within any information domain.

3.1 General Flow of Interaction

The design of the framework is tightly defined by the expected flow of the user. Considering this flow will inform the following design decisions outlined throughout this chapter. Figure 3.1 depicts this flow.

The expected user flow begins with reading a document. The user consumes the content of the document and follows by providing a confidence level representing the user’s overall confidence with the contents of the document. Following this, the user participates
Chapter 3. Design of the Framework

Figure 3.1: The general flow of the user through the Appollo framework

in a quiz that tests their knowledge about the content they have read. These quizzes should pose questions and provide the user with a number of predetermined answers. The user will provide their answer and proceed to provide a confidence level that represents their confidence with the correctness of the answer.

3.2 The Conceptual Model

Conceptualising and quantifying user knowledge has led to a number of design decisions to make the framework effective in encapsulating user knowledge. The conceptual model considers three models: the Expert Model, the Avatar Model and the User Model. Figure 3.2 outlines this in more detail.

These conceptual models each have a specific purpose in the framework and affords a quantitative approach to knowledge management. Firstly, consider the Avatar Model. The Avatar is an important design decision in the approach of the framework. The avatar models the user’s perceived knowledge. The perceived knowledge can be defined as the knowledge the user believes that they know after reading a document. If the user provides feedback that suggests that they have understood the concepts contained in the documents they have read then their avatar model will reflect this knowledge.

The Knowledge Rating defined in the avatar model is defined by the confidence level provided by the user when they have selected that they either know or do not know the concept contained in the document. This model is unique in the way it is defined when compared to the expert and user models.

The Expert and User Models are defined in the same way, though they define two distinctly different elements in the knowledge modelling framework. Initially, consider the definition of these models. Both models define the documents and associated questions within each. Each question informs the model by indicating a score attached to the answers provided for each quiz question presented.

The Expert and User models differ only in their intent. The Expert model defines a user that represents a perfect understanding of all concepts contained in the information space. Subsequently, the Expert model will always provide a correct answer to any question posed to it.

The User model defines the actual knowledge of the user; defined by their responses to questions asked of them by the framework. This differs from the perceived knowledge as the user is specifically providing responses to the distinct concepts that the questions within the information domain are aiming to test.

3.3 Knowledge Structure Overview

The conceptual models defined earlier are then utilized to create a knowledge management structure that considers the integration of the models, their relationships and connections with concepts, documents, questions and their associated answers. An overview of the structure can be seen in Figure 3.3.
3.3. Knowledge Structure Overview

Figure 3.2: All conceptual models in the Appollo Framework

The knowledge structure represents the design decisions made in order to create the framework and allow for the quantified measure of growth in knowledge. As an overview, the elements outlined here are in an integrated model and connected by their apparent relationships.

3.3.1 Documents, Questions & Answers

The central most piece of this structure are the documents. These documents contain information about the specified domain for learning; focusing on wellness. A complete information domain consists of a set of documents, as depicted in Figure 3.3.

Each of these documents has at least one question associated with it. These questions are also represented as a simple set. A document may have as many questions as the author of the information sees fit. However, the goal of these questions is to ensure that the concept attached to each document has been clearly tested by the set of questions. Similarly, each question within a document will have a simple set of answers associated with it. Moreover, one answer in this set must be specified as the correct answer to its question.
3.3.2 Learner Model Ontology

The learner model ontology relates to the high-level characteristics of the learner that is managing their knowledge using the Appollo Framework. This ontology defines the user’s knowledge as a set of concepts. Concepts are high-level abstractions of the information that is contained in a document or a set of documents. For documents to be contained in a concept they must have content that relates directly to this abstracted concept.

An example of a concept is, “Benefiting your posture”. All associated documents in this concept set must teach or inform the user on ways to improve or benefit their posture. The ideal case in this concrete example is for documents in this concept to provide exercises and/or therapy advice in order to offer some benefit to the learner’s posture.

3.3.3 User & Expert Knowledge Level

As described in the conceptual model, both the Expert and User models are defined in a very similar manner. However, the distinction between these is seen in the level of knowledge encapsulated by the model. The Expert user model must define a perfect level of knowledge whereas the user model must define the learner’s level of knowledge.

As shown in Figure 3.3, the Expert model contains a set of knowledge ratings. Each rating refers to the percentage of knowledge known about each concept contained in the information domain. This rating is expressed mathematically as:

\[ R(\text{expert}) = 100 \times D(C_j) \]
Where $D$ represents all of the documents that correspond to concept $C_j$. The constant value for 100 represents the maximum value possible for the confidence of a user response, therefore representing the maximal value for the knowledge rating; representing a perfect understanding of concept $C_j$.

The user model defines its knowledge rating in a similar way. It is possible that the user can be equated to the expert model if the learner displays that they have perfect knowledge. However, in every case outside of a perfect understanding the knowledge rating given to the user will be the expert’s knowledge rating for concept $C_j$ scaled by the confidence level entered by the user. This is represented mathematically by the following function:

$$R(\text{user}) = C \times D(Q, j)$$ (3.2)

Where $C$ is the confidence level indicated by the user and $D$ is all documents corresponding to the question that tests the concept $C_j$. The key difference exhibited by these two equations is that the expert’s rating is defined solely by the concept, however the user’s knowledge rating is defined by the questions that test the knowledge distinctly relating to the concept.

### 3.3.4 Avatar Knowledge Level

Given that the avatar is aiming to define the level of knowledge the learner perceives themselves to know, the definition of its knowledge rating is dependent on the documents that have been read by the learner. Similarly to the user knowledge level, the avatar’s rating is scaled by the confidence level provided by the learner. If the user believes they have understood a concept after reading a document but they select a low level of confidence, then the avatar should reflect a partial understanding of the document. As a result, the avatar’s knowledge rating is defined by the following function:

$$R(\text{avatar}) = C \times D(C_j)$$ (3.3)

Where $C$ is the confidence level indicated by the user and $D$ is all documents corresponding to the concept $C_j$. The scalar property $C$ will scale the rating appropriately and reflect the level of knowledge that the user perceives themselves to know, after reading a document of information.

### 3.4 The Use of Confidence

Confidence is used as a key design decision in the creation of the knowledge modelling framework as it is a contributing factor in the growth of knowledge in any learning environment. If a learner is confident with the content presented they are more likely to understand a greater portion of the information provided. As a result, it is necessary that this confidence be mapped into the quantified measure of knowledge.

Confidence is used throughout the framework whenever evidence is collected about the user’s knowledge. Learners provide confidence levels after they have read a document and after they have offered an answer to a question. This informs both the User and Avatar models about how confident on a scale of 0-100 the learner is with the high-level concept attached to the document or question presented to them.

The knowledge rating is directly affected by this confidence. A rating is a score that ranges from -100 to +100. Figure 3.4 displays the range and how it is determined.

Therefore, a confidence of 0% will always yield a knowledge rating of 0. However, in the case of an incorrect answer, with a confidence level of greater than 0% the knowledge
rating yielded will be $-100 \times C$ where $C$ represents the confidence level. Similarly, in the case of a correct answer and a confidence level greater than 0% the knowledge rating yielded will be $100 \times C$ where $C$ also represents the confidence level.

### 3.5 Content Sets

Creating a framework for user controlled knowledge modelling that offers a long term user model requires an ability to offer an extensible information domain. The framework aims to achieve this and does so through the design of its documents. Documents are created as a part of the content sets that encapsulate them. A content set is a simple, linear set of documents that belong to a specific domain, for example posture or physical activity. These content sets can be closely or sparsely linked to other sets within the framework, the only requirement is that they conform to the design of the framework.

### 3.6 Mobile Information Delivery

The Appollo framework has been designed for mobile information delivery as the result of a design decision in the creation of the documents within the information domain. The documents have been created as snippets. The definition of a snippet is a document that succinctly presents information that relates to its high-level concept. Each snippet is designed to be short and easily consumed on a small and highly personal device. As a result, these snippets are perfectly suited to consumption on a mobile device.
3.7 The Architecture of Appollo

The following architecture of Appollo considers the system at a lower level and maps closely to the systems implementation. The architecture consists of a model of the user, the user’s knowledge, the information domain and their associated relationships. Figure 3.5 outlines these elements and relationships; defining the architecture.

![Architecture Diagram]

Figure 3.5: The architecture design of Appollo

3.7.1 The Remote Connection

The architecture outlines an element titled the ‘Remote Connection’. This is used to denote a HTTP connection from any Appollo framework conforming user interface to the remote data store. The use of a remote connection allows the user controlled knowledge model to be an open and easily accessed by its owner.
Chapter 3. Design of the Framework

The benefits of the remote connection are two fold. Firstly, the user will be able to access their model from any device, including the one that created it. Secondly, the model is not tied directly to the device that created it, securing the information and preventing it from accidental loss or corruption due to the device’s constraints (i.e. its Operating System or computing environment).

Moreover, the benefits of this is extended by the portability of the user controlled knowledge management framework. Allowing other remote interfaces to connect to it affords a device agnostic framework that can be easily extended to new platforms for mobile information delivery or domains that have not yet been explored. This is increasingly possible as the research in pervasive computing continues to reveal new and innovative means of human computer interaction.

3.7.2 The Information Domain

The information domain element outlined in the architecture is modeled as a data object that contains a complete set of information to be presented to the user by the framework. This element is domain independent; the content of the information modelled may be from any discipline of information or research. However, it must be modelled in a specific format.

This element is a simple set or array of document objects that are modelled in the way defined by Figure 3.6.

![Diagram of Document Structure](image)

**Figure 3.6: The structure of the documents used by the framework**

As shown in Figure 3.6, documents consist of the following data items:

- **id**: This is an integer that contains a number that uniquely identifies each document.
3.7. The Architecture of Appollo

• **Title**: The title of the document.

• **Concept**: Each document is designed to inform the user about one specific concept that is contained within the information domain.

• **Content**: A data item containing the content of the document.

• **Questions**: A set of arbitrary length containing a number of question objects.

• **Question**: An object that describes a question to be presented to the user with the following elements:
  - **_id**: An integer that uniquely identifies the question.
  - **Title**: The question to be posed to the user.
  - **Correct Answer**: An integer that identifies which answer is correct.
  - **Answers**: A set of arbitrary length containing a number of answer objects.
  - **Answer**: An object that describes a possible answer to the question. This object contains the text for the answer and a unique identifier.

The concept element is key in the design of the information domain. The framework uses the high level concept to group the documents contained in the information domain. Concepts are used to discern the change in user knowledge in particular sub-areas of the information space.

Internally these documents are defined as objects described in XML. An example of an XML object describing a document can be seen below:

```xml
<document title="Common Posture Issues" concept="Posture Issues" _id="1">
  <source>http://posturepage.com</source>
  <content>
    "Stand up straight!" "Pull your shoulders back!" As children, we were told to have good posture. Yet we were seldom taught effective ways to accomplish this. Indeed, we were often not even told just what ‘good posture’ is.
  </content>
  <questions>
    <question _id="1">
      <title>Achieving and maintaining good posture is inhibited by?</title>
      <correct_answer _id="1">
        The information gap in understanding what good posture is
      </correct_answer>
      <other_answers>
        <answer _id="2">
          Not stretching before working out
        </answer>
        <answer _id="3">
          Maintaining a sedentary lifestyle
        </answer>
        <answer _id="4">
          Ignoring pain after long periods of sitting
        </answer>
      </other_answers>
    </question>
  </questions>
</document>
```
3.7.3 User Model Database

The user model database controls, defines and subsequently models three separate entities with the same underlying structure. Each model is used for uniquely different purposes. The expert user model is used to define a prospective user that could be considered an expert in the information domain. The expert is used to query the user and avatar models to determine whether the these have answered questions correctly.

Considering that each model is created in the same format, consider the following general definition of a user model in the Appollo framework.

The General User Model

The general user model is described diagrammatically in Figure 3.7. The user model is defined with the following elements:

- **_id**: A unique identifier for the user model.

- **Model Name**: A name for the model that is also the name of the end user.

- **Gender**: Either ‘Male’ or ‘Female’. This data item is used to personalise the user interface.

- **Evidence**: A key-value store or dictionary that is used to represent information that is directly related to the user’s knowledge within the information domain. The evidence dictionary then models the following elements:

  - **Concept**: A grouping of the documents within a specific and unique concept. Within each document a model of the questions that have been answered by the user are found. These questions contain two elements:

    * **Provided Answer**: An integer value representing the unique identifier for the answer provided by the user.

    * **Confidence**: An integer value representing the percentage for the confidence level provided by the user. The confidence level defines the user’s faith in their answer and can be in the range of 0-100.

This high level model is then used to create all three required entity types: the user, expert and avatar models.
3.7. The Architecture of Appollo

Figure 3.7: The general user model used to model all user entities in the framework

The Expert User Model

The expert user model is used by both the user and avatar models as a benchmark for testing the results of their quiz answers. In essence, when either the user or the avatar answers a question in the quiz, or is used to create the open user model the expert model is queried to determine the correct response. Creation of the user model is achieved by scanning the complete information domain and dynamically creating a user model in the form of the general user model. This model contains a set of documents, questions and their associated correct answers.

The user and avatar models query the expert model in the manner described by Figure 3.8.

The response from the expert model is a boolean result that indicates either a true or false value for whether the model making the query has answered the question correctly.

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Figure 3.8: Using the expert model to determine whether a question has been answered correctly.

The User & Avatar Models

The avatar model plays an important part in the user controlled knowledge modelling framework. There are two elements defined in this framework to manage the user’s knowledge. Firstly, the framework attempts to model the user’s perceived knowledge. This is defined as the knowledge that the user believes they have understood and gathered as a result of reading a document. Secondly, the framework models and tracks the user’s actual knowledge. The actual knowledge is gathered by tracking the responses provided by the user and this is matched to the high-level concept defined as a part of each document.

Using the avatar model’s definition of the user’s perceived knowledge a comparison between perceived and actual knowledge can take place. This comparison is created by measuring both models on the same scale. The quantified value used for this scale is defined by aggregating a score assigned to each piece of evidence provided by each model. Assuming that for each question the maximum score produced is 100, the score can be determined algorithmically in the following way:

```java
function determineScore(question_id, answer_id, confidence) {
    if (queryExpert(question_id, answer_id)) {
        return confidence;
    } else {
        return confidence * -1;
    }
}
```

Internally, the Appollo application models the avatar model as a component of the user model, as they are intrinsically linked. The application stores these models as JSON objects. Consider this example of the user and avatar model:

```json
{
    "_id" : "1",
```
3.7.4 User Interface

The Appollo framework is a device agnostic platform for user controlled knowledge management. The architecture defines the User Interface as a high-level concept that is easily interchangeable provided that the interface conforms to the framework. Due to this, the user interface can easily be replaced by a tablet device or a cloud based web application to
achieve the same result.

Given that this thesis plans on delivering information in a mobile format the user interface throughout the rest of this study will be modelled as a smartphone.

3.7.5 Local Cache

The nature of the smartphone is highly connected, through a number of mediums, such as cellular and Wi-Fi networks. However, in some remote cases the smartphone will not be connected to the Internet and as a result cannot contact the remote server. The local cache on the device is a key element in this case as it provides a replica of all of the models that have been requested via the remote connection.

Moreover, the benefit of utilising a local cache means that the application can provide a responsive user experience regardless of the strength of the device’s signal or connectivity.
CHAPTER 4

The User View

Figure 4.1: Appollo app icon

This chapter introduces Appollo as the implementation of the general approach described in Chapter 3; providing an overview of its user interface and details of its underlying design. The user controlled knowledge modelling framework was delivered to the user through the custom app developed on Apple’s iOS. The following sections outline the functionality of the app with a focus on the user’s view of the software. For each function, the key design decisions made in the creation of Appollo are highlighted and justified.

4.1 Registration

The registration process is designed to explicitly capture information about the user. The nature of this data is personal information that is used to personalise the systems inter-
Chapter 4. The User View

face. Primarily, the personalisation is defined by the user’s gender. This offers gender specific selections presented by the interface. This level of personalisation is used by the application to provide a tighter connection between the user and the interface. Utilizing the user’s gender means that the system can offer them Avatar’s that correspond to their gender, making the application look and feel customised to each user. Registration is an important factor in the design of the application as it enables Appollo to provide an authenticated login for each user while enabling multiple uses to interact with the same device.

Figure 4.2: Appollo app registration

The information provided in this form is the following:

• First & Last Name: used by the system to identify the model created for each user
• Email: unique email address to be used for authentication
• Password: any string provided by the user that was greater than or equal to six characters long
• Gender: either Male or Female; used to personalise the interface

The focus of this application is not the authentication of the user. The authentication is minimalist and provides at least some protection for the user’s personal information. Moreover, the use of passwords for information systems to protect data is pervasively used and expected when users provide personal information. Therefore, the authentication is focused on identifying the user and providing some protection of their data and user model.
Moreover, capturing the user’s first and last name furthers this minimalist personalisation. These data items are used to identify the model from the user’s perspective and provide a more simplistic means of logging in when returning to the application. Similarly, the user’s name is utilized by the system to provide personalised system messages in the form of “Welcome to Appollo, Anthony” and “Anthony, are you ready for a quiz?”.

4.2 Introductory Information

The gamification elements of Appollo are central to its goals and it is important that the user understands how these work. Given that these elements may involve unfamiliar notions it was clear that there needed to be some introductory information presented to the user after registration. The goal of this feature is to inform the user about the nature of Appollo. Figure 4.3 displays the flow of the introductory information.

The images shown above are presented to the user in sequence. Each item is designed to continue to build on the user’s understanding of Appollo. Moreover, it was used as a soft introduction to the functionality of the system and begins to expose the user to the use of the avatar. The use of the avatar was quickly identified as an unfamiliar notion. Users needed to be told about the avatar before they understood why they were choosing an avatar in the first place. The five screens of the introductory information are outlined in more detail below. However, as outlined in red in Figure 4.3 the user is shown that there are a total of six (6) screens in the introductory information. This sixth screen is used by the interface to signify the end of the introductory information and initiate the Avatar selection process.

What is Appollo? (1 of 5)

The first screen in the flow of introductory information quickly informs the user about the overarching goal of Appollo. Appollo is a learning tool that is “Taking the pain out of learning!” while collecting all of the user’s knowledge in one place. This is a succinct way of introducing the user to the application and ensuring that they are aware that Appollo is a learning tool for their mobile device.

Learn What You Want To (2 of 5)

This screen outlines the extensibility of the application. The user is not locked into any specific information domain. The user is informed that they will be able to choose the information that they care about before beginning the learning process. Users will be able to select from a range of learning packages that can either be associated or arbitrarily aligned to other packages in the framework.

Read Snippets (3 of 5)

The user must align themselves with the idea of a snippet. Snippets are the method of delivering information contained in the learning packages. Moreover, given the nature of mobile devices this screen is informing the user that they will be able to learn at their own pace, where every they are, whenever they feel as though they could spare the time to consume a snippet of content.
Chapter 4. The User View

Figure 4.3: Appollo introductory information

Build Your Avatar (4 of 5)

The Avatar is an important part of the Appollo framework. This screen aims to briefly introduce the user to their influence over their Avatar. The user will be able to build their Avatar’s knowledge throughout the span of their interactions with Appollo. The Avatar will reflect the user’s perceived knowledge and as a result as the user reads snippets from their selected information domain they will be informing the Avatar’s knowledge.
4.3 Logging In

Appollo is providing a tool for knowledge management for long term user modelling. In order to do this, users must be able to access their models over more than one session to continue to inform the long term user model. This is achieved by logging into the application. Figure 4.4 shows the user selection view and login form.

The Figure shows two ways of logging into Appollo for users who have already registered. If they have registered on the device they are currently using then the user will be able to tap their name and login with their password. Alternatively, if they have registered
with Appollo on a separate device they would be able to login by providing both their email and password.

4.4 Selecting a Learning Package

Selecting a learning package is an important feature included in the design of Appollo. The framework offers lifelong user knowledge modelling and aims to be from any information domain; affording information independence. The selection of a learning package allows this information independence. Users are able to select from a list of available packages that have been authored and added to Appollo. Figure 4.5 shows how a user could select to learn about either Posture or Physical Activity.

![Figure 4.5: Selecting a Learning Package](image)

The learning package selection interface provides an extensible list of packages. The goal for this feature is to afford the user the ability to learn about information that they are interested in. However, this selection does not exclude the user from changing the information domain at their will. If the user’s preference changes the information domain can be changed by simply selecting a new available package.

Figure 4.5 displays the interface with only 2 available learning packages. Given the extensibility of Appollo, the interface will adapt to additions of learning packages by providing scrolling functionality allowing the user to scroll up or down a gallery of packages that are available.
4.5 Snippet Design

The information presented by Appollo is in the form of snippets. Snippets are defined as a short, succinct and easily understandable documents of information. Snippets often include images to help illustrate the ideas encapsulated within them. The goal of each snippet is to quickly inform the user about one specific high-level concept as identified by the author of the snippet. Figure 4.6 represents two snippets contained in the posture learning package.

Figure 4.6: Some example snippets used by the posture learning package

As shown in Figure 4.6, the snippets are simplistic and easily legible. Each snippet is highly focused on providing information about the concept that has been defined by the author of the learning package. The two documents chosen here are slightly longer than the size of the smartphone's screen and as a result requires the user to scroll the document down as they are reading; an intuitive means of navigation.

An earlier iteration of the design planned to use a technique known as progressive disclosure for the presentation of snippets and its detailed information. Progressive disclosure helps to reduce the weight involved in reading large documents. However, as the design was refined it became clear that the technique was not as effective for the snippets contained in Appollo. The information is short and succinct and as a result the benefits of progressive disclosure were not transferred to the reading of snippets.
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The design of these snippets were focused on the delivery of information on a mobile device with a small screen and limited display space. Nielsen, 2011 studied user comprehension when reading content off mobile devices. The study concludes that comprehension scores collected off mobile devices were 48% of the desktop level when using an iPhone-sized screen. This study differs from the information presented in Appollo’s snippets as Nielsen’s test was designed for reading desktop formatted information on a mobile phone. However, the design of snippets meets the guidelines outlined by Nielsen as they are designed specifically for the mobile; snippets are short, succinct and do not try to teach more than one concept at a time.

4.6 Recommendations and Progress Scores

Appollo’s primary landing view contains two key design elements; the recommendation system and progress score interface. However, these two interface elements are displayed to the user in in the same view to promote user awareness. The recommender is a direct call to action, allowing the user to continue the learning process. Moreover, the progress scores that are located in the bottom half of the screen are status elements that are continually updated as the user navigates through the information space. These two elements are discussed in detail independently in the following sections.

4.6.1 Snippet Recommender

Each snippet collection or learning package can vary in its collection size. Given this variation in size, large data sets could suffer from becoming unwieldy for the user to manage. Appollo manages this by providing the user with a recommendation system that orders the documents according to their relevance to the user. This is defined by whether they have read and understood the snippets.

As discussed in Chapter 2 there are a number of types of recommendation systems that all provide recommendations based on different mechanisms. Appollo implements a content-based recommender system as the heuristic for recommending a snippet is as simple as querying the user model with respect to each snippet. A snippet will be recommended if the user has informed their model that the concept contained in the snippet has not be understood or a question associated with it has been answered incorrectly. Figure 4.7 displays two views of the recommendation system.

As the user consumes information and provides feedback to the system, the recommender continues to update itself to reflect the current state of the user model. The screen on the left hand side of Figure 4.7 shows two of the three categories used by the recommender. “Recommended” represents a subset of the snippets that have been recommended by the system and “To Do” represents a subset of snippets that correspond to concepts that are not yet contained in the user model.

The right hand screen shot of Figure 4.7 shows how the recommender defers but does not remove information that is of less importance to the user. The two categories in question here are “To Do” and “Done”. Intuitively, those snippets contained in the Done subset are those that have both been read and their associated questions have been answered correctly.

4.6.2 Progress Scores

Gamification has informed one of the main design decisions in increasing the engagement of Appollo. Gamification affords a level of engagement that has proven to take the pain out
of learning (M., 2002). An element of gamification that has been implemented in Appollo is the progress bar that models both the avatar and the user’s level of knowledge. These models are both measured on the same scale ranging from negative 100% to positive 100% of the knowledge contained in the information domain. Given that each learning package varies in size, the range of the progress score also varies. Figure 4.8 displays both the user and avatar progress scores.

In this instance both a positive and negative score is displayed. The user has a score of -400. This score is due to the fact that the user has provided a number of incorrect answers. In order to highlight the fact that the user has a negative score, the progress bar is coloured red. Moreover, the avatar’s score of +480 is indicating that the user has selected a high level of understanding for the snippets they have read. This represents the knowledge that the user thinks they know, whereas the user’s progress score is representing the knowledge the user actually knows. Given that the avatar’s progress score is greater than zero, its progress bar is coloured green. This highlights the positive level of knowledge of the avatar.

The progress bars are updated as the information changes. Directly after providing feedback to a document or selecting an answer to a question the model in question is updated. This feedback directly and instantly updates the progress bars. This feature is an important part of ensuring that the user is continually offered feedback; providing self-awareness of their progress. The design of the recommendation system is aimed at afford-
Chapter 4. The User View

Figure 4.8: Progress scores for both the User and their Avatar

The user view is a simplistic means of navigating through the information space. As displayed in Figure 4.7, the table is showing a maximum of 5 snippets within one view. Moreover, the use of the recommender means that the snippets displayed are typically ranked by their ability to continue informing the user. This allows the user to easily identify which snippets of information they can progress to in order to increase their knowledge.

4.7 Self-Assessment

An important part of the self-awareness that Appollo aims to offer is the affordance for users to assess their knowledge as they read their snippets. This level of self-assessment is captured directly after reading, forcing the user to assess themselves. The assessment is as simple as tapping either yes or no when presented with the question of understanding the concept contained in the snippet the user has just completed reading. This can be seen in Figure 4.9.

4.8 Confidence Rating

A key design decision in the creation of Appollo was to further the self-assessment elements of the interface. This design decision was inspired by the research presented in Chapter 2 that outlines the importance of the confidence of the learner in becoming self-
aware of their progress and feeling of knowledge \cite{Allwood2002}. This was achieved by asking the user how confident they were with every response they gave to inform the user model. The confidence rating is collected after reading a snippet and after responding to a question in a quiz. Figure \ref{fig:conf_rating} displays the interface that Appollo presents to the user allowing them to enter their confidence.

The confidence rating is represented as a maximum of a five star rating, where each star represents one fifth of 100%. In Figure \ref{fig:conf_rating} the confidence rating selected is 80%. This rating informs the user and avatar about the level of knowledge that the user has perceived themselves to know about the concept.

4.9 Scrutable User & Avatar Models

As discussed in Chapter 2, learning is highly dependent on the amount of feedback that is given to the learner. The learner must be able to identify whether they have made a mistake and how to rectify it. The model that is used to calculate the progress score for both the user and avatar is scrutable due to this fact. The scrutability enables the learner to inspect their progress. This progress is grouped by the concept of the snippet and the questions that have been presented to the learner. Figure \ref{fig:scrutable_models} displays two scrutable models one representing the User and the other the Avatar.

The scrutability of the user model is an important part of the design of the overlay model provided to the user. The view depicted in Figure \ref{fig:scrutable_models} allows the user to observe all of
Chapter 4. The User View

Figure 4.10: Selecting a Confidence Rating

the information that the system is storing about them. More specifically, the scorable user model is showing a set of subsets of snippets that are grouped by their concept. Within each snippet the associated questions that have been asked of the user are shown with feedback on the responses given by the user. The answer provided by the model is either correct or incorrect. Moreover, for each question is the confidence is displayed along with the score that has been awarded to each question. For each snippet, there is a subtotal displayed that aggregates the scores for the questions contained in the snippets.

4.10 Quizzing

Another element of gamification that further increases the engagement of the user experience is the quizzing functionality. Quizzes are an effective way of measuring the level of understanding that the user has about the content they have read. Moreover, the quiz is implemented as a game; challenging yourself against your avatar. Appollo will ask the user how often they would like to be quizzed after the user has registered. The user can select one of the following options:

- Every Snippet - the user will be asked whether they want to take a quiz after they have read one snippet
- Every 3 Snippets - after reading 3 snippets the user can enter a quiz
- Every 5 Snippets - after reading 5 snippets the user can enter a quiz
4.10. Quizzing

This quiz frequency is a setting that is changeable along with the avatar and learning package that the user has selected. The quiz interface is displayed in Figure 4.12.

The features outlined in Figure 4.12 are elements designed to maintain focus on one question at a time while maintaining context. The quiz is paginated, displaying a single question with its associated answers directly beneath it. The ordering of these answers is randomized. This random placement of answers is only ignored if an answer is “All of the above” or “None of the above” as they both have to be placed as the last option.

The randomization ensures that the user’s answer to each question does not afford a “process of elimination” to identify the correct answer. This means that if the user does not know the answer to a question they are required to go back and re-read the snippet to review the concept. This design decision is aimed at attempting to support the learner by facilitating a better understanding rather than awarding the logical process of elimination.

Finally, the quiz will only ever ask the user a maximum of five questions at a time. This is by design to ensure that the quiz does not overwhelm the user and specifically presents questions from the snippets that have been read most recently. Questions will no longer be displayed in the quiz if the user has answered them correctly with 100% confidence. Otherwise, there is a randomized chance that a question with an incorrect answer or low confidence level may appear again.
4.11 Avatar Response

Given that the quiz is a competitive game against the user’s avatar the interface must alert the user to the Avatar’s progress throughout. This is referred to as the Avatar Response View. The goal of this view is to challenge the user and create a gamified environment. To simulate the interactivity of the Avatar the response view confronts the user with an image of their avatar and the response that it gave. Figure 4.13 displays two avatar responses.

There are three elements to consider in this avatar response. Firstly, the response from the system that indicates whether the user was either correct or incorrect. Secondly, the response from the avatar; a simple string in the format “I answered ...” followed by the answer provided by the avatar, followed by whether the avatar was correct or incorrect. Thirdly, if the user provided an incorrect answer the correct answer will be displayed directly below the response from the system.
Figure 4.13: The Avatar Response View
The primary goal in the evaluation of Appollo was to assess the effectiveness of the framework in assisting users to learn on a mobile device. Moreover, an assessment of the major design decisions used in the creation of the framework was undertaken. The inclusion of gamification as a means of measuring the user’s progress within the information domain was a key design decision that aimed to offer a painless growth in user knowledge. In addition, the consideration that confidence is a factor in the learning process required validation by the evaluation process.

Testing these elements of the Appollo framework was achieved by qualitative analysis. The qualitative analysis afforded observations of each user as they interacted with Appollo. These observations collected a standard set of responses that were captured as a result of the think-aloud usability study, interview and questionnaire that each participant was asked to complete. Moreover, throughout this process general comments were collected by the observer of the study to capture the user’s behaviour, body language and reactions to the software.

5.1 Hypotheses

The experimental evaluations of this framework were tested against the following hypotheses that have aimed to inform the study about the key design decisions and their effect on participants.

\[ H_0: \text{The interface will allow users to easily navigate through potentially large information domains.} \]

This hypothesis aims to understand whether the Appollo interface facilitates the process that users will have to undertake while attempting to navigate
through a large set of snippets that have been authored in their selected information domain. An effective learning tool must facilitate the user’s growth in knowledge. Potentially large datasets can become overwhelming for learners. As a result, it is important that learners do not feel submerged in content. The navigation through content should feel easy and simplistic.

**H1: Gamification made the learning experience engaging and fun.**

The elements of gamification that were included in the design of Appollo were implemented with the aim of engaging users in this learning context. Moreover, this engagement has been associated with taking the pain out of learning. As a result, proving this hypothesis aims to show whether the learning experience in Appollo offers the participants a fun and engaging way of expanding their knowledge.

**H2: The Avatar was a useful tool in measuring the difference between the user’s actual and perceived knowledge.**

One of the key design decisions in the creation of the knowledge modelling framework is the Avatar. The Avatar was designed to quantify and measure the difference between the user’s perceived knowledge and actual knowledge. This is a novel idea that has no baseline system to be compared against. As a result, the aim of this hypothesis is to gather information from users about the intuitiveness of the Avatar. The selection of an Avatar should be an obvious and intuitive function of the framework. Moreover, the user should have a clear understanding of the purpose of the Avatar and be able to observe the quantifiable difference between their perceived and actual knowledge.

**H3: The inclusion of confidence levels to the learning process prompted self-awareness and self-monitoring of knowledge.**

Confidence levels of participants when consuming content and testing their knowledge plays an important part in the learning process. Confidence affords the participants a unique opportunity to ask themselves whether they are confident with the information they have read or the answer they have provided. This intrinsic question provides an additional objective for Appollo as it further extends its goals; becoming a self-assessment tool. Self-assessment is often a powerful tool in the expansion of a learner’s knowledge. This hypothesis aims to find out how effective the self-assessment tool is in the knowledge modelling framework.

**H4: The interface will enable users to easily recover from errors through effective error messaging that facilitates self-diagnosis.**

An effective interface should provide the user with feedback that will enable them to diagnose an error if they encounter one. Typically, this can be achieved by providing error messages that match the system to some real-world understanding. For example, if the system is unable to process a request, the error message that the user receives should provide some steps to enable them to correct the process.

**H5: The interface should be easily learnable for users with no prior experience with it.**
Learnability of the user interface is an important factor in the design of usable system. Facilitating a simple means of user interaction will provide users with the ability to quickly adapt to the user interface. An effective user interface will impose a very modest learning curve. This can be achieved by supporting the user throughout their interactions and ensuring that calls-to-action are used sparingly.

5.2 Participants

The experimental study was conducted with a total of 14 recruited participants. Each evaluation was conducted individually in a closed participant and observer environment. Participants did not necessarily have any prior relationship to each other. The recruitment process was conducted by extending an invite to a total of 20 potential participants that were either friends or family of the observer. Given that the study required participants to volunteer on average fifteen minutes of their time some participants declined the invitation. Of the 14 that accepted the invitation, their ages ranged from 17 to 66 and 57% of these were female. 21% of these participants had a background in computer science and the remaining 79% of these had no background in computer science, usability or related fields. All participants had experience using smart phones and custom applications on these devices. Table 5.1 shows an analysis of the participants with regard to their age, background and time spent in the study.

5.3 Experimental Design

The experiments were designed to be carried out in one domain of information; wellness. Wellness was chosen as a the specified information domain as it is generally applicable to people of all walks of life and can offer some benefit to the participants. The evaluations offered information about either posture or physical activity. Users were asked to pick one aspect of this information domain at the beginning of their session. This selection stayed persistent throughout the study.

There were three elements conducted for each experiment. Each part aimed at capturing the user’s understanding of the Appollo framework. However, the goal of these when aggregated was to capture a holistic understanding of each participant’s ability to use the interface and learn something new while being engaged in the game-like elements of the framework.

5.3.1 Think-Aloud Usability Evaluations

The primary means of evaluating the Appollo interface was conducted through a think-aloud usability evaluation. A think-aloud enables the participant to naturally interact with the system while providing feedback throughout. The think-aloud asked each participant to perform a total of eleven tasks. The tasks that each participant was asked to achieve are outlined in Table 5.2.

The Task Name outlined for each task in Table 5.2 was used as a internal method of identifying the task and not the actual message delivered to the participant in the Think-Aloud Usability Study. The message used to prompt the participant to achieve each task was altered slightly to suit the participant’s background. For example, for those participants with a background in computer science, task 10 was presented to them in the form
Table 5.1: A list of participants in the study

<table>
<thead>
<tr>
<th>ID</th>
<th>Gender</th>
<th>Age</th>
<th>Time Spent</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male</td>
<td>22</td>
<td>8 minutes</td>
<td>An information systems student in their 3rd year. Has extensive experience with smart phone devices.</td>
</tr>
<tr>
<td>2</td>
<td>Male</td>
<td>18</td>
<td>10 minutes</td>
<td>A high school student who had just completed the HSC. Has extensive experience with smart phone devices.</td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>22</td>
<td>14 minutes</td>
<td>A computer science student with extensive experience on smart phone and tablet devices.</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>52</td>
<td>15 minutes</td>
<td>A business man with who owns a smart phone, though has novice skills when using it.</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>17</td>
<td>13 minutes</td>
<td>A high school student who had just completed his HSC. Has experience with the use of mobile devices.</td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>23</td>
<td>16 minutes</td>
<td>A computer science student in their 5th year of study. Has extensive skills with mobile devices.</td>
</tr>
<tr>
<td>7</td>
<td>Female</td>
<td>45</td>
<td>11 minutes</td>
<td>A stay at home mother with very little experience in the use of smart phone devices.</td>
</tr>
<tr>
<td>8</td>
<td>Female</td>
<td>17</td>
<td>20 minutes</td>
<td>A high school student who just finished her HSC. She has experience with using smart phones and custom apps.</td>
</tr>
<tr>
<td>9</td>
<td>Female</td>
<td>43</td>
<td>8 minutes</td>
<td>A graphic designer that works for a small to medium enterprise. She is a novice smart phone user.</td>
</tr>
<tr>
<td>10</td>
<td>Female</td>
<td>18</td>
<td>12 minutes</td>
<td>A high school student who had just completed her HSC. Extensive experience with smart phones.</td>
</tr>
<tr>
<td>11</td>
<td>Female</td>
<td>17</td>
<td>12 minutes</td>
<td>A high school student who had just completed her HSC. Extensive experience with smart phones.</td>
</tr>
<tr>
<td>12</td>
<td>Female</td>
<td>21</td>
<td>21 minutes</td>
<td>A computer science student in her 4th year of study. Has extensive experience with smart phone devices.</td>
</tr>
<tr>
<td>13</td>
<td>Female</td>
<td>66</td>
<td>20 minutes</td>
<td>A stay at home mother who owns a smart phone device but has trouble with its interface.</td>
</tr>
<tr>
<td>14</td>
<td>Female</td>
<td>20</td>
<td>21 minutes</td>
<td>An apprentice hair dresser that has been using a smart phone for a year.</td>
</tr>
</tbody>
</table>

Table 5.1: A list of participants in the study

of “Determine how your score was calculated” whereas those participants that had no technical background were asked to “Find out how your score was created”.

Each of these tasks aimed to enable the study to provide evidence to support the hypotheses. Each hypothesis was tested rigorously by the tasks in the study; an analysis of
5.3. Experimental Design

<table>
<thead>
<tr>
<th>#</th>
<th>Task Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Register with Appollo</td>
<td>Participants need to register with the framework in order to create their model. Their interactions with the framework will store their model in a persistent datastore for analysis.</td>
</tr>
<tr>
<td>2</td>
<td>Read through the app description information</td>
<td>Initially the participant needs some introduction to the application. This information is designed to inform the user about the purpose of the Avatar and quizzes that they will be interacting with. Any confusion is recorded by the observer.</td>
</tr>
<tr>
<td>3</td>
<td>Select an Avatar</td>
<td>The participant should be able to quickly identify and select their avatar. At this point the use of the Avatar should be intuitively understood by the participant.</td>
</tr>
<tr>
<td>4</td>
<td>Select a quiz frequency</td>
<td>Each participant was afforded the opportunity to select a quiz frequency; selecting one of the following: every 1, 3 or 5 snippets.</td>
</tr>
<tr>
<td>5</td>
<td>Select a learning package</td>
<td>Given the extensible nature of the framework selecting a learning package will enable the user to learn about information they are concerned with. Participants were able to choose from either posture or physical activity.</td>
</tr>
<tr>
<td>6</td>
<td>Read a snippet and provide feedback</td>
<td>The information domain is made up of snippets that are simple and succinct. Each participant was asked to read a snippet of their choosing and provide feedback.</td>
</tr>
<tr>
<td>7</td>
<td>Select a confidence level</td>
<td>After providing feedback the participant is asked to select their confidence by providing a 0-5 star rating.</td>
</tr>
<tr>
<td>8</td>
<td>Read enough snippets to trigger a quiz</td>
<td>Given the variable nature of the quiz frequency some participants would need to read up to 5 snippets to trigger a quiz. After which they will complete the quiz.</td>
</tr>
<tr>
<td>9</td>
<td>Read a minimum of 10 snippets and conduct at least 5 quizzes</td>
<td>In order to conduct a rigorous test and inform each participant’s user model a total of 10 snippets and 5 quizzes will achieve this.</td>
</tr>
<tr>
<td>10</td>
<td>Inspect the user model</td>
<td>The participant should be able to identify the role of their confidence level and the calculation of their score.</td>
</tr>
<tr>
<td>11</td>
<td>Inspect the Avatar model</td>
<td>The participant should be able to identify the role of their confidence in informing and building their avatar’s knowledge.</td>
</tr>
</tbody>
</table>

Table 5.2: Tasks that each participant was asked to achieve

this is outlined in Table 5.3.

Throughout the process the observer was able to offer guidance and help to the participant if they found themselves stuck with some element of the interface. However, the participant was not interrupted as the observer’s role was to guide the participant towards overcoming a challenge or difficult task.

Each task was allocated an expected time to complete range which was used to determine when to assist the user to ensure they were not frustrated but struggling with the system. For example, Task 1, “Register with Appollo” was assigned 60 seconds. If 60 seconds elapsed before the task was completed and the participant appeared to be struggling the observer would guide them towards completing the task. All such cases were recorded and reported in Table 5.4.
Chapter 5. Evaluation

<table>
<thead>
<tr>
<th>Task ID</th>
<th>H0</th>
<th>H1</th>
<th>H2</th>
<th>H3</th>
<th>H4</th>
<th>H5</th>
</tr>
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<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>4</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>5</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>8</td>
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<td>✓</td>
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<td>✓</td>
<td>✓</td>
</tr>
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<td>✓</td>
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<td>✓</td>
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<td>✓</td>
</tr>
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<td>10</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>11</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 5.3: Think-Aloud Usability tasks compared with the hypotheses of the study

5.3.2 Participant Questionnaire

Each participant was asked to complete a questionnaire after conducting their think-aloud usability evaluation. The questionnaire was aimed at gathering qualitative data. The nature of the qualitative data informs the hypotheses of the study. Each hypothesis is directly targeted by the questionnaire. The following questions were asked of each participant:

1. **On a scale of 0-5 how engaging was Appollo?** This question is designed to understand the level of engagement the participant was feeling throughout the study.

2. **What was the point of the Avatar?** This question aimed to understand whether the inclusion of the avatar was intuitive and generally comprehended by participants. This question informs Hypothesis 2.

3. **Did you find Appollo challenging?** This question further informs Hypothesis 1; identifying whether the gamification elements created an engaging environment for learning.

4. **How was your score calculated?** This question informs Hypothesis 3; an understanding of the role of confidence in the calculation of the participant’s score.

5. **How was your Avatar’s score calculated?** This question informs Hypothesis 2; capturing the participant’s understanding in their role of informing the knowledge of their avatar.

Each of these questions relates directly to a hypothesis in the study. This question and hypothesis relation is detailed in Table 5.3

5.3.3 Participant Interview

In addition to the questionnaire each participant was asked five questions in the interview process. The interview afforded the participant the opportunity to provide open ended qualitative information about their impressions of the framework. The following questions were asked of each participant:

1. **Would you use Apollo again and why?** Capturing the participant’s intention to use the framework in the future shows how engaging and useful the application was.
5.3. Experimental Design

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Task ID</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>1</td>
<td>This participant was a novice iPhone user who had trouble inputting data to the registration form. The user took a particularly long time to complete the task. The observer did not have to intervene, just continue to remind the user that there was no time limit to the usability study.</td>
</tr>
<tr>
<td>13</td>
<td>7</td>
<td>The participant was confused about the stars when inputting their confidence level. They commented “Those stars represent each question?” The observer provided an alternative interpretation of this in order to guide the user to a correct understanding.</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>The participant was unsure about the introductory information and asked if the information was telling her about the app or asking her to interact with it.</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>The participant was unsure of what a snippet was and paused before selecting their quiz frequency.</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>The participant commented “I have no idea what this is about yet”, the observer had to inform the participant that the introductory information was provided to them to introduce them to Appollo</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>The participant did not realise that the stars presented to her to represent her confidence level were interactive. The observer corrected this the next time the participant was entering their confidence level.</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>The participant saw the confidence selection as a slider not as a selection of stars. This was quickly rectified once the user attempted to select a confidence level for the first time.</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>The participant struggled to understand how they could inspect their user model. The participant was confused with the scrutability of the model and required the observer to explain the task in more detail without intervening with their interactions with the system.</td>
</tr>
</tbody>
</table>

Table 5.4: Report on the participants that struggled with the system

<table>
<thead>
<tr>
<th>Question ID</th>
<th>H0</th>
<th>H1</th>
<th>H2</th>
<th>H3</th>
<th>H4</th>
<th>H5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>3</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>4</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Table 5.5: Questionnaire questions compared with the hypotheses of the study

2. **Were the snippets you read accessible, easy to read and succinct?** The content used in the usability evaluations could be challenging or non-engaging. As a result, the question aims to understand whether the content used in the study was obtrusive and detracted from the usability of the application. Conversely, if the content used for the study was created simply and succinctly then it should help aid the engage-
ment of the study.

3. **Did you feel challenged by the Avatar?** In order to further inform hypothesis 1, this question asks the participant if they felt like they were being challenged by their avatar when being quizzed.

4. **What was 1 thing that you liked about Appollo?** This open ended question allows the participant to offer positive and constructive criticism for the further development of the application.

5. **What is 1 thing that you would improve Appollo on?** This positively positioned question allows the participant to offer constructive criticism without feeling apprehensive about providing negative feedback.

In the same manner as the questionnaire, each of these questions relates directly to a hypothesis in the study. These relationships are outlined in Table 5.6.

<table>
<thead>
<tr>
<th>Question ID</th>
<th>H0</th>
<th>H1</th>
<th>H2</th>
<th>H3</th>
<th>H4</th>
<th>H5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
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<td>✓</td>
</tr>
<tr>
<td>5</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 5.6: Interview questions compared with the hypotheses of the study

### 5.4 Results

Given the qualitative nature of the data that has been collected throughout the evaluation process, an analysis has been undertaken to compile these into quantifiable results. The analysis takes each evaluation task and question into consideration and compares the results with the index outlined in Table 5.8. The quantifiable data coded by the index is then used for analysis to inform the hypotheses of the study.

#### 5.4.1 Coded Results

Each participant’s usability study has been coded by the index defined earlier to provide the following analysis. Each participant has been given an ID (from 1-14) and has been allocated either a ✓ or ×. Allocation of a ✓ is only possible if all indices allocated to each hypothesis have been passed by the participant. For example, for Hypothesis 0, if the participant passes index 1 but fails index 2 therefore they would be allocated a × for the grounded analysis of each hypothesis.

These coded results are depicted in Figure 5.1 displaying the percentage of participants that satisfied each hypothesis.

**Analysing Hypothesis 0**

The analysis for each hypothesis shows that there was a minimum of 57% of participants providing a positive coded response. The analysis shows that hypothesis 0 has had a clear translation to a highly usable interface for the participants in the study. All users in the
### 5.4. Results

#### Hypothesis Criteria

1. **H0** Throughout the think-aloud usability study if the participant does not have trouble navigating between snippets or reading a snippet in the first place they will be informing this hypothesis.

2. **H0** In the interview if the participant answers positively to the question *Were the snippets you read accessible?* they will be providing positive feedback for H0

3. **H1** If the participant provides an engagement score of 4 or 5 in the questionnaire they have displayed that the framework was engaging.

4. **H1** If the participant responds Yes to the question *Did you feel challenged by the Avatar?* they will be providing evidence to support the hypothesis

5. **H2** When answering the question *What was the point of the Avatar?* if the participant provides a response that mentions the ability for knowledge management

6. **H2** When inspecting the Avatar’s score in the think-aloud usability study if the participant is able to identify the reason their score differs from their Avatar’s they will be providing positive evidence to support this hypothesis

7. **H3** When selecting a confidence level in the think-aloud usability study the participant should take due consideration before entering their confidence. This can be indicated by body language or the comments that they have made while undertaking the task

8. **H3** In the questionnaire the participant is asked to identify how their score and their Avatar’s score has been calculated. If the participant indicates that confidence influences both scores they will be providing evidence to support this hypothesis

9. **H4** Throughout the study if participants identify an error and are able to over come the error on their own. If the participant is unable to overcome the issue and requires the observer’s intervention then they will be providing evidence to negatively support the hypothesis

10. **H5** If the participant does not struggle when attempting to achieve a task then the hypothesis can be supported. Moreover, analysing the responses to Q3 in the questionnaire and Q4 and 5 in the interview, can support this hypothesis.

<table>
<thead>
<tr>
<th>#</th>
<th>Hypothesis</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H0</td>
<td>Throughout the think-aloud usability study if the participant does not have trouble navigating between snippets or reading a snippet in the first place they will be informing this hypothesis.</td>
</tr>
<tr>
<td>2</td>
<td>H0</td>
<td>In the interview if the participant answers positively to the question <em>Were the snippets you read accessible?</em> they will be providing positive feedback for H0</td>
</tr>
<tr>
<td>3</td>
<td>H1</td>
<td>If the participant provides an engagement score of 4 or 5 in the questionnaire they have displayed that the framework was engaging.</td>
</tr>
<tr>
<td>4</td>
<td>H1</td>
<td>If the participant responds Yes to the question <em>Did you feel challenged by the Avatar?</em> they will be providing evidence to support the hypothesis</td>
</tr>
<tr>
<td>5</td>
<td>H2</td>
<td>When answering the question <em>What was the point of the Avatar?</em> if the participant provides a response that mentions the ability for knowledge management</td>
</tr>
<tr>
<td>6</td>
<td>H2</td>
<td>When inspecting the Avatar’s score in the think-aloud usability study if the participant is able to identify the reason their score differs from their Avatar’s they will be providing positive evidence to support this hypothesis</td>
</tr>
<tr>
<td>7</td>
<td>H3</td>
<td>When selecting a confidence level in the think-aloud usability study the participant should take due consideration before entering their confidence. This can be indicated by body language or the comments that they have made while undertaking the task</td>
</tr>
<tr>
<td>8</td>
<td>H3</td>
<td>In the questionnaire the participant is asked to identify how their score and their Avatar’s score has been calculated. If the participant indicates that confidence influences both scores they will be providing evidence to support this hypothesis</td>
</tr>
<tr>
<td>9</td>
<td>H4</td>
<td>Throughout the study if participants identify an error and are able to over come the error on their own. If the participant is unable to overcome the issue and requires the observer’s intervention then they will be providing evidence to negatively support the hypothesis</td>
</tr>
<tr>
<td>10</td>
<td>H5</td>
<td>If the participant does not struggle when attempting to achieve a task then the hypothesis can be supported. Moreover, analysing the responses to Q3 in the questionnaire and Q4 and 5 in the interview, can support this hypothesis.</td>
</tr>
</tbody>
</table>

Table 5.7: The index used to code each participant’s responses

---

Study showed that the interface was effective in providing an easy and simple means of navigating through potentially large data sets.

**Analysing Hypothesis 1**

Moreover, hypothesis 1 had 71% of participants provide positive evidence to support it. Engagement was clearly displayed by participants in the study; this was reflected by their responses to the questionnaire. Figure 5.2 shows a percentage break down of the engagement value selected by participants.

As shown above, the minimum response provided by participants was a value of 3 out
Chapter 5. Evaluation

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>11</th>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
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<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
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</tr>
<tr>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 5.8: The index used to code each participant’s responses

Figure 5.1: Percentage of participants that satisfied each hypothesis

![Bar chart showing the percentage of participants that satisfied each hypothesis]

Figure 5.2: Engagement values selected by users

![Pie chart showing engagement values selected by users]

of 5; indicating a highly positive response for the engagement of Appollo. In addition to this, participants provided positive comments that referenced one of the following key terms: fun, engaging, gaming or challenging. Comments such as “It was actually really
fun once you got going!” (participant 8) and “I’m going to lose this game!” (participant 10) showed that these participants understood that they were engaging in a game and were finding themselves challenged by the process. This is compounded by participant 9’s commented “I actually learned something... [it’s] an engaging and fun way of learning”.

Analysing Hypothesis 2

Hypothesis 2 was tested using indices 5 and 6. The aim of this hypothesis is to understand the role that the participants perceived the Avatar to play. The intention was to utilise the avatar as a measurement tool, however communicating this to the user was not a simple task. Given that 54% of the participants were able to provide positive evidence to support it, there are a few elements to consider. Firstly, it was apparent that throughout the test the understanding of the Avatar was built throughout the participant’s interaction. A trend was clearly identified by observation of the participants; initially participants said that they were confused about the role of the Avatar. However, throughout the course of reading snippets and participating quizzes 57% of participants found themselves providing positive evidence to support hypothesis 2.

Moreover, participants commented the point of the Avatar was to “To outline the two different types of knowledge. That is, what an individual thinks they know and what they actually can recall” (participant 5) and “A personal marker to compete against. This allows gamification of knowledge.” (participant 3). These responses show that users who understood the use of the Avatar had a clear understanding of its goals. Conversely, these that did not understand the Avatar at the end of their study commented that “To teach me about posture” (participant 7) and “To give a personal touch” (participant 1). These two comments suggest two possible misunderstandings; that the avatar was trying to teach them about the granular information domain that they have selected and that its primary role was to personalise the interface. While the latter was an indirect goal of the Avatar as it did offer Appollo a level of personalisation, the true goal of the Avatar eluded them.

Analysing Hypothesis 3

Hypothesis 3 directly addresses the self-awareness goals of the Appollo framework. Confidence levels provided by the participants displayed the level of self awareness that they had throughout the study. Confidence levels also had an impact on the calculation of the user and Avatar scores that were presented to each participant. It was clear that the confidence levels prompted self evaluation by each participant; this was observed throughout the study by monitoring user behaviour as well as the average confidence score provided by users. Figure 5.3 depicts the average confidence scores provided by each participant when giving feedback about the snippets they have read.

It is clear that the confidence levels fluctuated drastically from participant to participant. This displays that each participant took due consideration when selecting their confidence after reading a snippet. Moreover, the fluctuation shows that users did not ignore the selection of confidence and intuitively understood why confidence was a consideration of the scoring of the user and avatar models. In one isolated case with participant 4, the participant ignored or did not understand the use of confidence in the first few instances of their response; recording some responses with 0 confidence. This skews the participants overall average confidence level. As a result, this participant has the lowest average.

Generally, the confidence levels selected were above 50%. This could be due to the simple nature of the information domain as both the Posture and Physical Activity domains used in the usability evaluation were constructed succinctly, providing exactly the right
Chapter 5. Evaluation

Figure 5.3: The average confidence score provided by each participant after reading a snippet

Given the accessibility of this information, the confidence levels can be expected to be quite high.

Considering that there are two ways in which participants were able to provide confidence levels, it is important to consider each separately in order to identify any trends in the data. Figure 5.4 depicts the confidence levels provided after answering a question in any one of the quizzes that the participant undertook.

Figure 5.4: The average confidence score provided by each participant after answering a question in a quiz

These confidence levels are generally high and follow a similar trend to the confidence levels provided when reading the snippets. Comparing these two graphs will reveal whether participants were more or less confident when being presented with a question rather than reading a snippet. A comparison of these confidence levels is shown in Figure 5.5.

When comparing the two types of confidence, there is a clear relationship. The trend for both kinds of confidence is clearly similar, however, the fluctuation for confident users tends to be negative when responding to questions in a quiz. This shows that participants
5.4. Results

Figure 5.5: A comparison of the average confidence score provided by each participant after answering a question in a quiz and reading a snippet.

were generally less confident with the knowledge once they were asked about specific pieces of information from the information they had read. This displays the clear distinction between perceived and actual knowledge. However, asking participants to complete a quiz showed whether the participant actually absorbed the information and converted it into knowledge they could recall. Given that this is now a quantifiable measure, it is important to show the difference in the scores calculated for each model. Figure 5.6 displays the difference between the avatar and user model scores.

Figure 5.6: A comparison of the user and avatar scores calculated for each participant.

The scores vary drastically in many cases. Participants often found it hard to match or better their Avatar’s score. This continues to illustrate the significant difference between the perceived and actual knowledge displayed by the participants. Participants 9 and 10 had a calculated score of 0, indicating that they had made no progress in the information domain; they had provided an even amount of correct and incorrect answers at the same level of confidence. Moreover, these results provide insight into the types of confidence that each user exhibited; either over or under confidence. As discussed in Chapter 2, these measures in confidence can have negative effects on the participants ability to
Chapter 5. Evaluation

learn. Analysing the confidence data has shown that 28% (Participants 1, 2, 6 and 13) of participants were over-confident of their knowledge. This assessment is defined by the participant’s avatar score being significantly higher than their actual score.

These participants responded the disparity in the user and avatar scores with the following comments:

- “I want to beat her!” and “The avatar was a fierce challenger” - Participant 13
- “Yes [the Avatar was challenging]. The avatar was always ahead of me and always getting it right!” - Participant 6
- “[The avatar was challenging] because I made him really smart!” - Participant 1
- “He [the avatar] seemed to know more about it than I did” - Participant 2

These comments show that the participants that were over-confident found that the Avatar was challenging; engaging them and encouraging them to achieve a better result.

These results show that in some cases the framework is able to model a participant's actual knowledge to be exactly the same as the individual’s perceived knowledge. As a result, the framework effectively models user knowledge and is able to provide participants with clear, quantifiable and an ultimately measurable tool for effective self-awareness of the growth in their knowledge.

Analysing Hypothesis 4

Effective error messaging and facilitating self-diagnosis when errors are encountered provides an easy to use interface with a modest learning curve. These two elements were considered in the design of the Appollo interface. The index shows that throughout the study 6 of the 14 participants struggled in some way with the system. However, only 1 of these participants required the observer’s intervention to overcome the error they had made. As a result, this shows that only 7% of users in the study were unable to diagnose the problem they were having on their own; while utilizing the feedback from the system.

In the case of participant 6 and 13 and their misconception with the selection of confidence levels the participants were easily able to self-diagnose the error they were having by analysing the feedback from the system. This feedback was discrete as the system did not present an error message. However, the way in which the control objects used for the selection of confidence reacted to the participants input was enough to inform them of their mistake. This provides evidence that supports the self-diagnosis element of this hypothesis though it suggests that in some isolated cases error messages are not necessary to guide the user in the right direction.

Moreover, the other reported incidents showed that there was less confusion with the interface itself and more confusion with the functionality of Appollo; the understanding of the avatar and associated gamification elements in the non-gaming context caused the challenges that participants 8, 10 and 12 encountered.

Analysing Hypothesis 5

The overall learnability of the interface used to drive Appollo was measured in this study by observing participant behaviour and analysing their responses to questions in the questionnaire and interview. Observations throughout the think-aloud usability studies have shown that the system is easily learnable. Users were able to dive straight into the system and were continually asking questions that pre-empted the tasks that they had to undertake.
5.5 Conclusions

For example, participant 3 at the start of the study commented “I’m going to register to start with.”

Moreover, responses to the Q3, “Did you find Appolo challenging?” of the questionnaire, have been analysed to in order to further inform the analysis of this hypothesis. The question is open-ended and can refer to the challenging nature of the Avatar or the challenges that participants found in the interface. Table 5.9 reports on these responses.

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Question ID</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Q3 (Questionnaire)</td>
<td>“Not in terms of usability”</td>
</tr>
<tr>
<td>2</td>
<td>Q3 (Questionnaire)</td>
<td>“No. The application was easy to use”</td>
</tr>
<tr>
<td>1</td>
<td>Q3 (questionnaire)</td>
<td>“As a game it is straight forward”</td>
</tr>
<tr>
<td>10</td>
<td>Q3 (Questionnaire)</td>
<td>“Yes when trying to remember facts, but it was set out nicely.”</td>
</tr>
<tr>
<td>9</td>
<td>Q3 (Questionnaire)</td>
<td>“More informative than challenging”</td>
</tr>
</tbody>
</table>

Table 5.9: Participant responses that relate to the usability of the interface

In addition to this Q4, “What was 1 thing you liked about Appolo?” and Q5, “What was 1 thing you would improve on?” in the interview are both open-ended questions that afforded the participant the ability to provide feedback on the interface. The feedback often came in the form of suggestions for extensions to the functionality or alterations of the design to make it more accessible. Table 5.10 reports on these comments.

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>“Make it more fun! Less like a quiz and more like a game.”</td>
</tr>
<tr>
<td>10</td>
<td>“More frequent quizzing is better; makes the game easier”</td>
</tr>
<tr>
<td>13</td>
<td>“The questions in the quiz should be numbered.”</td>
</tr>
<tr>
<td>6</td>
<td>“It would help me if I could change the text size. Break some of the content up over multiple pages.”</td>
</tr>
<tr>
<td>1</td>
<td>“Build a better understanding of the rating system”</td>
</tr>
</tbody>
</table>

Table 5.10: Participant responses that relate to the usability of the interface

These general comments and observations throughout the study were specifically aligned at improving the system. Participants did not mention that the interface was hard to use or was confusing at any point of the study. As discussed in the previous section, the challenges that participants encountered were often observed when there was confusion with the objectives of the system, rather than the design and control elements of the interface.

5.5 Conclusions

The evaluation of this study aimed at providing insight into the six hypotheses. Each hypothesis aimed to test a specific design goal in the creation of the Appolo framework and relate directly to the goals of the study. The primary goals of the study were: (1) to understand the role of gamification in providing an engaging learning environment, (2) provide an effective means of learning about potentially large information domains through mobile information delivery and (3) to model and quantify the user’s knowledge.

Considering these goals, the results of the study directly informed each in some significant way. Consider goal (1). The results that informed Hypothesis 2 showed that there
was an obstacle to overcome in the communication of the role of the Avatar. However, once this unfamiliar notion was established by the user Apollo’s gamified learning environment was highly engaging. Moreover, the results displayed that users were encouraged and challenged by the Avatar; promoting learning and providing an effective platform for the growth of their knowledge.

Evaluating goal (2) primarily considers the results of Hypothesis 1. However it also includes Hypotheses 4 and 5 as they contain usability requirements that enhance the user’s ability to achieve this goal. Users in the study encountered challenges with the interface when selecting confidence levels or registering with the application. However, there were no reports of users begin lost or incapable of finding the next snippet they should read. The recommender system implemented in Appollo proved to be an effective way of deferring information that was less applicable to the user’s context; facilitating simplistic navigation through a large information domain.

Hypothesis 4 and 5 with regard to goal (2) evaluated the usability and learnability of the application. The links in these results to this goal are obvious as large information domains can be overwhelming for the learner. Given that the system was able to afford users the ability to self-diagnose errors that they encountered and required a very modest learning curve, the ability for the user to navigate through the information domain was enhanced.

Evaluating goal (3) considers the framework’s role in quantifying the two types of knowledge; perceived and actual knowledge. This goal considers both hypothesis 2 and 3. Firstly, the inclusion of confidence and the intuitive acceptance of users to provide confidence levels for feedback given to the system highlighted its effectiveness. Confidence provided a means of quantifying this knowledge as it afforded a way of scaling the user and avatar scores to represent the user’s knowledge.

Quantifying this data offers no benefit if the user is unable to measure their performance and monitor their progress. Due to this, the results collected for hypothesis 2 continue to inform goal (2) of the study. The inclusion of the avatar provided a mechanism to measure the difference between the user’s perceived and actual knowledge.

In conclusion, the Appollo framework for user controlled knowledge modelling of mobile information delivery was able to offer users a new way of managing and tracking their knowledge. The engaging, challenging and ultimately fun environment stimulated learning and proved to be effective in quantifying user knowledge.
Appendix 1: Supporting Wellness Documents

6.1 ‘Snippets’ Used by Appollo

The following are references to documents, or snippets, used by the Appollo framework to model its user’s knowledge. Each document is indexed by its associated concept or construct, relating to wellness. Moreover, each document has an associated number of questions, each of these are outlined in this section.

Common Posture Issues

**Source**: http://posturepage.com  
**Concept**: Posture Issues  
“Stand up straight!” “Pull your shoulders back!” As children, we were told to have good posture. Yet we were seldom taught effective ways to accomplish this. Indeed, we were often not even told just what “good posture” is.

The consequences of this information gap can be seen all around us: stiff necks, shoulders hunched forward or pulled tightly back, restricted breathing, and tightness in the thighs, legs and ankles. Backaches, headaches, and other painful symptoms are often the unfortunate result.

**Questions**

1. Achieving and maintaining good posture is inhibited by?
   
   (a) The information gap in understanding what good posture is (correct answer)
   
   (b) Not stretching before working out
Chapter 6. Appendix 1: Supporting Wellness Documents

(c) Maintaining a sedentary lifestyle
(d) Ignoring pain after long periods of sitting
(e) All of the above

Benefits of Yoga

Source: http://posturepage.com/yoga/index.html

Concept: Benefiting Your Posture

Yoga views a person's posture as a physical manifestation of one's inner state. One's view of the world and one's mental, emotional and spiritual state reflects in one's general deportment, including how one postures oneself.

Deficiency in posture often begins in childhood with lack of awareness which becomes habitual and self-sustaining. This pattern becomes further reinforced and perpetuated by the stress in our lives and chronic neuromuscular tension. Yoga can change this.

Conscious static stretching is the first step. This is how you begin to penetrate and disintegrate the old status quo, that is, the chronic patterns of neuromuscular tension which have been sustaining less than optimal posture.

Questions

1. Your posture is a reflection of...
   (a) Your mental, emotional and spiritual state (correct answer)
   (b) Your genetics
   (c) Good discipline
   (d) Good breathing
   (e) All of the above

2. Yoga effectively releases...
   (a) Chronic neuromuscular tension (correct answer)
   (b) Biomechanic tension
   (c) General aches and pains
   (d) Tight muscles
   (e) All of the above

Increasing Your Benefit From Yoga

Source: http://posturepage.com/yoga/index.html

Concept: Benefiting Your Posture

To increase your benefit it’s important to understand that the stretch is just the beginning of a process which needs to be completed. The stretch creates a magic moment: by releasing tension, the stretch makes the neuromuscular system receptive to positive change. You want to take full advantage of this.

Right after your major stretches i.e. several times each class, you simply recline on your back and, with eyes closed, you completely “let go”. You drop off into a sort of “half-sleep, half-awake” state where the relaxation feels so good you just don’t want to
move. It's known as “deep alpha” in biofeedback, referring to slowed brain-wave activity occurring during deep meditative states. This is the secret.

Yoga stretching combined with such deep relaxation enables a natural re-organization of the tension holding patterns within the neuromuscular system, one benefit being better posture. This is the key which awakens yoga’s legendary benefit to the fullest.

Questions

1. The magic moment caused by Yoga...

   (a) Makes the neuromuscular system receptive positive change (correct answer)
   (b) Ensures deep relaxation
   (c) Ensures a good stretch
   (d) Re-organizes your tension holding patterns
   (e) All of the above

CranioSacral Therapy

Source: http://posturepage.com/cranio/index.html

Concept: Posture Therapy

According to CranioSacral philosophy postural alignment is dependent on a free and open connective tissue system throughout the body. Connective tissue surrounds and supports all of the structures of our body and when it is restricted can cause tugging and pulling on these structures which can result in postural malalignment.

Restrictions can be caused by trauma, both physical and emotional, or by habitual holding patterns in the body due to stress and dis-ease. CranioSacral therapy helps in locating and gently releasing these connective tissue restrictions, freeing the trauma or holding patterns, allowing for free movement and overall well being.

A typical CranioSacral session lasts about a hour, with the patient lying comfortably on a massage table fully clothed. The CranioSacral therapist uses his or her hands to gently free restrictions in various parts of the body. The work is very soothing and relaxing in nature and the effects of a session can often be felt right away, although sometimes they are not fully apparent until hours, or even days later.

Questions

1. Connective tissue is important to posture as it...

   (a) Surrounds and supports all of the structures in our body (correct answer)
   (b) Part of the philosophy of CranioSacral philosophy
   (c) Restricts your movement
   (d) Causes habitual holding patterns in the body
   (e) All of the above
Chapter 6. Appendix 1: Supporting Wellness Documents

Physical Therapy


Concept: Posture Therapy

In the practice of physical therapy posture is a concept frequently used in examining people and determining if treatment, particularly for back and neck problems, has made any changes in a person. Posture is defined as "the position or bearing of the body" (Websters Medical Dictionary) and refers to the overall alignment of the various body parts to each other when the person is standing in a relaxed stance.

The ideal posture is assumed to be when the earlobe, tip of the shoulder, hip joint and outside bump (malleolus) of the ankle all lined up on a plumb line. The center of the knee is slightly in front of that line. This arrangement is viewed as indicating that a person's overall structure is in good mechanical balance.

Variations from this ideal give the therapist clues as to areas of the body that do not permit the full mechanical ability for which they are designed. It is the restoration of the mechanical abilities that then will permit the person to have "better" posture that is the goal of physical therapy with these people. The techniques to restore these abilities may include exercise, stretching, massage and other soft tissue techniques, modalities such as heat, ice and ultrasound, and re-education in movement patterns and positions during activities.

Questions

1. The ideal posture is assumed to be when the earlobe, tip of the shoulder...
   
   (a) hip joint and outside bump of the ankle are all lined up on a plumb line. (correct answer)
   
   (b) The center of the knee are lined up
   
   (c) Are balanced and aligned
   
   (d) And ankles are aligned.
   
   (e) None of the above

2. Posture is defined as...
   
   (a) The position of the body (correct answer)
   
   (b) The overall alignment of the body
   
   (c) The straight-ness of the body
   
   (d) Various parts of the body being aligned when standing
   
   (e) None of the above

Thai Chi

Source: http://posturepage.com/taichi/index.html

Concept: Posture Therapy

In Tai Chi Chuan, posture is related to mechanical efficiency. Tai Chi Chuan is a slow-moving choreography that asks its practitioners to sense each minute shift of weight while paying attention to its principles. The first principle Lift the head suggests we delicately lift the head as if we were supporting a light object on top of it. There is a specific spot on the crown of the head that should extend towards heaven. This idea keeps the practitioner lengthening the spine and consciously improving posture during practice.
6.1. ‘Snippets’ Used by Appollo

The second is Standing in Posture. This means holding one posture for a period of time instead of moving from posture to posture. “Standing in a Posture” puts more weight on one leg than the other. Tiring in that posture, the leg you are standing on starts to talk back. It hurts. It is under tremendous load. The proper response is to find any holding or bracing and let go, releasing those muscles. As the muscles are releasing, the spine is lengthening.

Tai Chi Chuan not only improves posture and balance while doing the Tai Chi form, but in everyday activities as well.

Questions

1. How many Thai Chi principle(s) are there?
   (a) 2 (correct answer)
   (b) 5
   (c) 7
   (d) 1
   (e) 3

2. The first principle of Thai Chi is...
   (a) Lift the head - lift the head and shoulders as if we were supporting a light object (correct answer)
   (b) Lift the leg - lift a leg as if we were supporting a light object
   (c) Lift the arm - lift an arm as if we were supporting a light object
   (d) Standing in Posture - hold one posture for a long time
   (e) None of the above

3. The second principle of Thai Chi is...
   (a) Standing in Posture - hold one posture for a long time (correct answer)
   (b) Lift the leg - lift a leg as if we were supporting a light object
   (c) Lift the arm - lift an arm as if we were supporting a light object
   (d) Lift the head - lift the head and shoulders as if we were supporting a light object
   (e) None of the above

Osteopathy and Posture

Source: http://posturepage.com/osteopathy/index.html

Concept: Posture Therapy
Osteopathic treatment concentrates on the relationship between the structure of the body - the skeleton, muscles, ligaments and connective tissue - and the way in which the body moves and functions. The literal meaning of the word osteopathy is ‘bone disease’ - a rather unfortunate term that does nothing to evoke the great benefits of this safe, natural system of diagnosis and treatment.

The therapy was devised in the 19th century by an American doctor, Andrew Taylor Still. He became disillusioned with medicine when three of his children died of viral meningitis. Still sought an alternative in the philosophy of Hippocrates, who claimed that
the 'cure of disease lies within the body'. An interest in osteopathy developed through his belief that tension in muscles and misaligned bones places unnecessary strain on the body. This strain can be caused by any number of things, such as physical injury, bad posture, or by emotions such as anger and fear.

Whatever the cause, Still believed it could be eased by adjusting the framework of the body, so that all the systems within it would run smoothly and the body could heal itself.

Questions

1. The literal meaning of osteopathy is...

(a) Bone disease (correct answer)
(b) A system of complementary medicine involving the treatment of medical disorders
(c) The manipulation of the skeleton and musculature
(d) A treatment for poor posture
(e) All of the above

2. Osteopathy was created by a belief that...

(a) tension in muscles and misaligned bones places strain on the body (correct answer)
(b) Bad posture can lead to serious illness
(c) Good posture will improve your wellbeing
(d) Aligning your body properly will improve your health
(e) None of the above

Identifying Good Posture

Source: http://www.wikihow.com/Improve-Your-Posture

Concept: Benefiting Your Posture

Good posture is nothing more than keeping your body in alignment. What it looks like when standing is a straight back, squared shoulders, chin up, chest out, stomach in. If you can draw a straight line from your earlobe through your shoulder, hip, knee, to the middle of your ankle you’ve got it.

Using a mirror, align your ears, shoulders, and hips. Proper alignment places your ears loosely above your shoulders, above your hips. Again, these points make a straight line, but the spine itself curves in a slight 'S'. You’ll find that this doesn’t hurt at all. If you do experience pain, look at your side view in a mirror to see if you’re forcing your back into an unnatural position.

The spine has two natural curves that you need to maintain called the 'double C' or 'S' curves, these are the curves found from the base of your head to your shoulders and the curve from the upper back to the base of the spine. When standing straight up, make sure that your weight is evenly distributed on your feet. You might feel like you are leaning forward, and look stupid, but you don’t.
Questions

1. **Good posture looks like a straight back, squared shoulders and...**
   
   (a) Chin up, chest out and stomach in (correct answer)
   
   (b) Legs a shoulder’s width apart
   
   (c) Chin up, chest in and stomach out
   
   (d) Chin up and stomach out
   
   (e) All of the above

Train Your Muscles to Do the Work

**Source:** http://www.wikihow.com/Improve-Your-Posture

**Concept:** Benefiting Your Posture

Exercises that strengthen the muscles across your upper back and shoulders will help you maintain good posture. You don’t need to develope a body builder physique it's more important to build "muscle memory" so that you unconsciously, naturally, maintain correct posture without fatigue. Try the following, with or without hand weights:

**Exercise One**:

- Square your posture, head upright, so that your ears are aligned over your shoulders
- Raise both arms straight out, alongside your ears, palms up
- Bend forearms in and back, toward shoulders, in an effort to touch your shoulder blades with your fingertips
- Do ten repetitions with both arms, then alternate ten reps for each arm singularly.

**Exercise Two**:

- Align ears with shoulders as in Exercise One
- Raise both arms out to sides at shoulder height, and hold for a slow count of ten.
- Slowly lower arms to sides, counting ten as you lower
- Slowly raise arms back to shoulder height, counting to ten as you raise arms
- Do ten reps, constantly checking your alignment with each rep. If ten reps are too many to start, do as many as you can. You should at least feel a slight fatigue in the shoulder muscles.

Questions

1. **Good posture can be maintained by...**

   (a) Strengthening the muscles across your upper back and shoulders (correct answer)
   
   (b) Being diligent and aware of your posture
   
   (c) Develop a body builder physique
   
   (d) Sitting up straight
   
   (e) All of the above
Chapter 6. Appendix 1: Supporting Wellness Documents

Be a Penguin

Source: http://www.wikihow.com/Improve-Your-Posture

Concept: Benefiting Your Posture

While you wait for a web page to load, bread to toast, popcorn to pop or the microwave to beep, place elbows at your side, and touch your shoulders with your hands.

Keeping your hands on your shoulders and your ears aligned, raise both elbows (count one, two) and lower them back down (count one, two). Do as many reps as your wait allows. You’ll be surprised how much exercise fits into 30 seconds.

Questions

1. ‘Be a Penguin’ refers to...
   (a) A strengthening exercise for maintenance of good posture (correct answer)
   (b) Living in a cold climate
   (c) Develop a short and stubby physique
   (d) Sitting up straight
   (e) Sliding around on your belly

Improve Your Posture By Doing Stretches

Source: http://www.wikihow.com/Improve-Your-Posture

Concept: Benefiting Your Posture

This can greatly help if you find that you have a sore back or neck. It’s also good to do during the day, if your job requires you to sit for long periods.

Tilt or stretch your head in all four directions over your shoulders (forward, back, left, right), and gently massage your neck. Avoid rolling in a circle, as it may cause further strain.

On your hands and knees, curl your back upwards, like a cat, and then the opposite. Think about being able to place a bowl in the hollow of your back.

Repeat the exercises a few times each day. Doing them in the morning helps your body stretch out the muscle lethargy of sleep, and periodically throughout the day helps raise your energy level without a heavy workout.

Questions

1. A quick exercise that counteracts sitting for extended periods is...
   (a) Tilting or stretching your head in all four directions over your shoulders (correct answer)
   (b) Going for a long run
   (c) Walking in the park
   (d) Doing 20 push ups
   (e) Doing 20 sit ups
6.1. ‘Snippets’ Used by Appollo

Excercising while at your computer (Step 1)

**Source:** http://www.wikihow.com/Exercise-While-Sitting-at-Your-Computer

**Concept:** Posture Exercise

Observe the proper sitting posture in a good chair that is designed for desk work. Your back should be straight, your shoulders back, and the top of your monitor should be level with your eyes. If you have to look down or up, then you need to adjust the height of your screen. Also, make sure that your wrists do not lie on the keyboard or on the mouse pad (unless you have a pad with a wrist rest). This will help prevent the onset of carpal tunnel syndrome (compression of the wrist that can result in pain, loss of feeling and weakness).[1] Keep your legs bent at the knees so that the knees are only slightly higher than your hips. Feet should be flat on the floor or on a step stool of some sort.

Questions

1. **The top of your monitor should be at what level?**
   - (a) At eye level (correct answer)
   - (b) forehead level
   - (c) Chest height
   - (d) In front of you
   - (e) All of the above

Excercising while at your computer (Step 2)

**Source:** http://www.wikihow.com/Exercise-While-Sitting-at-Your-Computer

**Concept:** Posture Exercise

Do simple stretching exercises. Stretch your arms, legs, neck and torso while sitting. This will help prevent you from feeling stiff. Neck: To stretch your neck, slowly flex your head forward and backward, side to side and look right and left. This can be done almost any time to lessen tension and strain. Never roll your head around your neck this could cause damage to the joints of the neck. Shoulders: Roll your shoulders forward around 10 times, then backward. This helps release the tension off your shoulders. Arms and shoulders: A good stretch for your arms and shoulders is to brace your hands on the edge your desk, each about a shoulder width away from your body. Twist your hands in so they point toward your body and lean forward, hunching your shoulders. Take this a step further and push your shoulders and elbows closer to the desk. Wrists: Roll your wrists regularly, around every hour or so. Roll the wrists 10 times clockwise, then 10 times counterclockwise. This will help minimize the potential for getting carpal tunnel syndrome if you spend a lot of time typing. Ankles: Roll your ankles regularly. As with your wrists, roll the ankles in a clockwise motion three times, then counterclockwise. This helps improve blood circulation, and prevents that tingling feeling you can get when blood circulation is cut off, also known as "pins and needles". Chest: Notice if you tend to hunch in front of the keyboard. To counter that, perform the following exercise: Open your arms wide as if you were going to hug someone, rotate your wrists externally (thumbs going up and back) and pull your shoulders back. This stretch is moving your body the opposite way to being hunched and you should feel a good stretch across your upper chest. Abdomen: Contract your abdominal and gluteal muscles, hold them there for a few seconds, then release. Repeat this every few minutes all day long while you're working at your desk. You can also perform kegels (pelvic floor exercises) while sitting. Calves: Stretch your calves. While sitting, lift up
your legs on the balls of your feet and set them down. Repeat until your legs are comfort-
ably tired. Repeat about 10 minutes later, and continue doing this routine for about an hour
or so. This will exercise your calves, and will help prevent blood clots from developing in
your legs. Blood clots are very common among middle-aged computer users.

Questions

1. Why should you do simple exercise while sitting?
   (a) To ensure that you don’t get stiff” (correct answer)
   (b) for fun
   (c) To ensure you work at a better rate
   (d) So you are sitting in the correct position
   (e) All of the above

Excercising while at your computer (Step 3)

Source: http://www.wikihow.com/Exercise-While-Sitting-at-Your-Computer

Concept: Posture Exercise

Stand up every half hour to walk around a bit. This will ensure continuous blood circulation
in your arms and legs, and will keep them from getting too strained. Take walks to the water
station to refill your glass. If you can afford to take longer breaks, take a short walk outside
your building, and use the stairs instead of the elevator to go down. Aside from giving your
legs and heart a good workout, you can take in some fresh air as well.

Questions

1. Why should you stand up every half hour and walk around?

   (a) To ensure that you have continuous blood flow in your arms and legs (correct
       answer)
   (b) so that you are excercising
   (c) To get a drink
   (d) So you can get some fresh air
   (e) All of the above

Excercising while at your computer (Step 4)

Source: http://www.wikihow.com/Exercise-While-Sitting-at-Your-Computer

Concept: Posture Exercise

Give your eyes a break from focusing on your screen. Every 30 minutes or so, shift your
focus from the computer screen and scan around other subjects in the room, such as a
window, clock, desk, or door. This helps promote eye movement and lessens chances of
eye irritation and headaches. Another technique to relax your eyes would be to rub your
hands together, then place your cupped hands over your eyes.
Questions

1. What does it achieve by shifting your focus from the computer screen?

   (a) It promotes eye movement which in turn lessens chances of eye irritation (correct answer)
   (b) so you can see all the objects in the room
   (c) To spot other people in the room
   (d) So you can look at the paintings on the wall
   (e) All of the above

Excercising while at your computer (Step 5)

Source: http://www.wikihow.com/Exercise-While-Sitting-at-Your-Computer

Concept: Posture Exercise

Take advantage of the downtime created by rebooting or large file downloads. Get up and take short walks around your floor. If you can find the space to do it and do not have many co-workers around who would be bothered, try something more ambitious such as doing a few push-ups, sit-ups, and/or jumping jacks.

Questions

1. What are some recommended tasks that you can undertake while waiting for your computer to re-boot?

   (a) Push-ups, Sit-ups and/or jumping jacks (correct answer)
   (b) Do not move from your chair
   (c) stay focused on the computer screen
   (d) Do nothing at all
   (e) All of the above

Excercising while at your computer (Step 6)

Source: http://www.wikihow.com/Exercise-While-Sitting-at-Your-Computer

Concept: Posture Exercise

Do exercises with the help of a few tools. The following tools may be helpful: Acquire a hand gripper. These are cheap, small and light, easily kept tucked in a desk drawer. When you have to read something either on the screen or on paper, you probably won’t be needing to use your hands very often, so use this opportunity squeeze your gripper. It is an excellent forearm workout. Acquire an elastic band. This is also cheap, small and light. Use it to do the actions mentioned above (such as, when stretching your arms, do it by pulling apart the elastic band). This will stretch and work the muscles slightly. Invest in a large size stability ball or stability ball-style desk chair. Sit on it with your back straight and abs firm. You will burn calories stabilizing your core and body on the ball. While an actual stability ball is more effective, the chair is usually a more viable option to use in an office environment. While sitting or talking on the phone, you can bounce or do basic toning exercises. Use the actual ball form in moderation when typing, as this is probably not the most supportive seating to prevent carpal tunnel and tendinitis.
Chapter 6. Appendix 1: Supporting Wellness Documents

Questions

1. **What are some recommended tools to use?**
   
   (a) Hand gripper (correct answer)
   
   (b) A House
   
   (c) Another person
   
   (d) Do nothing at all
   
   (e) All of the above

**Exercising while at your computer (Step 7)**


*Concept:* Posture Exercise

Take a few deep breaths. To work your abdominal muscles, hold your stomach for a few seconds when breathing in, then release when breathing out. If possible, get some fresh air in your lungs by taking a walk outside, as mentioned in a previous step.

Questions

1. **Taking deep breaths works what muscle group?**
   
   (a) Abdominal (correct answer)
   
   (b) Biceps
   
   (c) Calf
   
   (d) Hamstrings
   
   (e) All of the above

**Exercising while at your computer (Step 8)**


*Concept:* Posture Exercise

Have a bottle of water by your side and make a habit of drinking plenty of water throughout the day. If you do this consistently, you will begin to feel more alert. Take trips to the water refilling station to refill your jug or glass, so that you can also walk around and exercise your legs at the same time.

Questions

1. **Constantly drinking water will help to?**
   
   (a) Make you more alert (correct answer)
   
   (b) make you sleepy
   
   (c) Slow down your work rate
   
   (d) distract you
   
   (e) All of the above
6.1. ‘Snippets’ Used by Appollo

How to do a Push Up (Step 1)

Source: http://www.wikihow.com/Do-a-Push-Up
Concept: Posture Exercise
Remember to always warm up before any exercise. Warming up reduces the risk of injury, [1] and gets muscles ready to do a push up. You can actually lift/push/pull/etc more if you go through a proper warm up routine, as compared to diving straight into the exercises. Make sure to stretch your arms and wrists - key joints in push ups.

Questions

1. why must you warm up?
   (a) To reduce the chance of injury (correct answer)
   (b) To increase the chance of injury
   (c) Because it is fun
   (d) It will distract you from your task ahead
   (e) All of the above

How to do a Push Up (Step 2)

Source: http://www.wikihow.com/Do-a-Push-Up
Concept: Posture Exercise
Assume a prone position on the floor or other rigid surface (preferably carpeted-more on that later) that’s able to support your body weight. Keep your feet together!

Questions

1. How do you position your feet
   (a) Together (correct answer)
   (b) Apart
   (c) One on the floor, one in the air
   (d) Wherever is comfortable
   (e) All of the above

How to do a Push Up (Step 3)

Source: http://www.wikihow.com/Do-a-Push-Up
Concept: Posture Exercise
Position hands palms-down on the floor, approximately shoulder width apart. If you are on a relatively cushioned surface, such as a carpeted floor, you may also support yourself on your fists between the first and second knuckles for a greater challenge. If you are on a less forgiving surface, consider investing in some pushup grips (they look like handles you put on the floor.) Curl your toes upward (towards your head) so that the balls of your feet touch the ground.
Chapter 6. Appendix 1: Supporting Wellness Documents

Questions

1. **What part of your foot should touch the ground?**
   - (a) Balls of your feet (correct answer)
   - (b) Heels
   - (c) Toes
   - (d) Bottom of your foot
   - (e) All of the above

How to do a Push Up (Step 4)


*Concept*: Posture Exercise

Raise yourself using your arms. At this point, your weight should be supported by your hands and the balls of your feet. Make a straight line from your head to your heels. This position is called a "plank," which is used for other various exercises. This is the beginning and the end position of a single push-up.

Questions

1. **How should you raise yourself**
   - (a) With your arms (correct answer)
   - (b) with your legs
   - (c) With your chest
   - (d) With your arms and legs
   - (e) All of the above

How to do a Push Up (Step 5)


*Concept*: Posture Exercise

Lower your torso to the ground until your elbows form a 90 degree angle. Keep your elbows close to your body for more resistance. Keep your head facing forward. Try to have the tip of your nose pointed directly ahead. Draw a breath as you lower yourself.

Questions

1. **How should you lower yourself**
   - (a) With your arms (correct answer)
   - (b) with your legs
   - (c) With your chest
   - (d) With your arms and legs
   - (e) All of the above
6.1. ‘Snippets’ Used by Appollo

How to do a Push Up (Step 6)

Source: http://www.wikihow.com/Do-a-Push-Up

Concept: Posture Exercise

Raise yourself by attempting to push the ground away from you.

Breathe out as you push. The power for that push will inevitably come from your shoulders and chest. The triceps (the muscle on the back side of your upper arm) are also contracted but the primary exercise for the triceps isn’t the push-up. Continue the push until your arms are almost in a straight position (but not locked). Repeat steps 4 and 5 for the remainder of the exercise.

Questions

1. **Where does the power of your push come from**
   
   (a) Shoulder and chest (correct answer)
   
   (b) your legs
   
   (c) your biceps
   
   (d) your arms and legs
   
   (e) All of the above

How to do a Push Up (Step 7)

Source: http://www.wikihow.com/Do-a-Push-Up

Concept: Posture Exercise

Raise yourself by attempting to push the ground away from you.

Pick the type of pushup that works best for you. There are actually three types of push ups that use different muscles. Note: The closer your hands are together the more you will engage your triceps and chest, the wider apart the more you will engage your chest. Closest-hand Regular Wide-arm.

Questions

1. **What pushup engages your triceps and chest the most**
   
   (a) closest-hand (correct answer)
   
   (b) wide arm
   
   (c) regular
   
   (d) wide arm and regular
   
   (e) All of the above

How to do a Push Up (Step 8)

Source: http://www.wikihow.com/Do-a-Push-Up

Concept: Posture Exercise

Stretch the chest and shoulder muscles during your cool down cycle. Proper stretching and cool down routines are just as important as the warm up, but, unfortunately, are quite often overlooked.
Questions

1. **What part of exercise is quite often overlooked**
   
   (a) cool down (correct answer)
   
   (b) warm up
   
   (c) The workout
   
   (d) warm up and cool down
   
   (e) All of the above

Standing Postural Muscles

**Source**: http://www.exrx.net/ExInfo/Posture.html

**Concept**: Postural Muscle Groups

The diagram to the right illustrates how the body is held erect. The thick black lines represent the principal muscles involved in standing. The vertical dotted line indicates the center of gravity. Note this line falls behind the axis of rotation of the hip and in front of the knee. This renders the ligaments of the joints tense, which are represented by dotted lines passing in front of the hip (ilio-femoral) and behind the knee (posterior ligament).

Questions

1. **What does the image demonstrate**
   
   (a) How the body is help erect (correct answer)
   
   (b) how the body moves
   
   (c) Why the body moves
   
   (d) The direction in which the body moves
   
   (e) All of the above

Lordosis

**Source**: http://www.exrx.net/ExInfo/Posture.html

**Concept**: Postural Muscle Groups

Pelvis is position forward and downward. Hips are slightly flexed and lumbar spine is excessively hyperextended. Hip flexors, erector spinae are short. Abdominal, hamstrings, gluteus maximus muscles may be weak. Increased risk of lower back injury during standing or lying hip extension, flexion, or stabilization activities, and weighted overhead activities. See abdominal weakness and hip flexor inflexibility. Examples of affected exercises: Squat Hack Squat Military Press (standing) Roman Chair Situp Example preventative / corrective exercises: Hip Flexor: Kneeling Hip Flexor Stretch Erector Spinae: Lower Back Stretch Abdominal: Crunches Hamstrings: Leg Curl Gluteus: Seated Leg Press

Questions

1. **What position is the pelvis in**
   
   (a) forward and downward (correct answer)
   
   (b) forward and upward
6.1. ‘Snippets’ Used by Appollo

(c) backwards and upward  
(d) Backwards and downward  
(e) All of the above

Posterior Pelvic Tilt

Source: http://www.exrx.net/ExInfo/Posture.html  
Concept: Postural Muscle Groups  
Sometimes referred to as flat back, posterior pelvic tilt involves the reduction of the natural lumbar curvature. This posture is characterized by the shortening of the hip extensors (Hamstrings & Gluteus Maximus inflexibility), tight abdominals, and lax hip flexors. It is rarely brought about by lack of muscular strength. The posterior pelvic tilt is less common as the anterior tilt as seen with lordosis. Examples of affected exercises: Leg Press Squat Straight Leg Deadlift Example preventative / corrective exercises: Hip Flexor: Lever Hip Flexion Hamstrings: Lying Hamstring Stretch Gluteus: Seated Glute Stretch Abdominal: Abdominal Stretch

Questions

1. What is posterior pelvic tilt sometimes referred to as
   (a) Flat back (correct answer)  
   (b) Curved back  
   (c) Straight back  
   (d) No Back  
   (e) All of the above

Kyphosis

Source: http://www.exrx.net/ExInfo/Posture.html  
Concept: Postural Muscle Groups  
Exaggerated anterior-posterior curvature of the vertebral column, most often involves an excessive forward bending in the thoracic area. Kyphosis occurs in older adults, particularly women with osteoporosis and osteoarthritis. Kyphosis is sometimes accompanied with other posterior problems such as posterior pelvic tilt and protracted shoulder girdle. Kyphosis makes it difficult to include overhead exercises particularly when combined with a winged scapula condition or shoulder external rotation inflexibility. Examples of affected exercises: Shoulder Press Seated Triceps Extension Front Squat Corrective exercises for gravity induced kyphosis: Strengthening of thoracic vertabral column extensors Stretching of thoracic vertabral column flexors

Questions

1. What age group does kyphosis occur in
   (a) Older Adults (correct answer)  
   (b) Young Children  
   (c) Teenagers  
   (d) Middle aged children  
   (e) All of the above
Forward Head Posture

Source: http://www.exrx.net/ExInfo/Posture.html

Concept: Postural Muscle Groups
An anterior positioning of the cervical spine is characteristic of forward head posture. Forward head posture may make it more difficult to perform exercises with the bar in front of head or neck. Evaluate neck position at night since elevating head too high with additional pillows may act as a continuous neck stretch throughout the evening exacerbating the forward head posture.

Examples of affected exercises:
• Shoulder Press
• Corrective exercises for gravity induced kyphosis
• Strengthening of cervical vertabral column extensors
• Stretching of cervical vertabral column flexors
• Neck Retraction

Questions
1. An anterior positioning of the cervical spine is characteristic of what posture
   (a) Forward head posture (correct answer)
   (b) Sitting posture
   (c) Poor Posture
   (d) Standing posture
   (e) All of the above

Winged Scapula

Source: http://www.exrx.net/ExInfo/Posture.html

Concept: Postural Muscle Groups
Inferior angle of scapula protrude slightly from body. A winged scapula condition may be accompanied by a protracted shoulder girdle. Risk of shoulder injury is compounded with a supraspinatus weakness or an external shoulder rotation inflexibility. Because of the forward tilt of the scapula, complete flexion of the shoulder may be seemingly restricted. A winged scapula condition indicates a definite serratus anterior weakness. The rhomboids may weak and the pectoralis minor may be short. Examples of affected exercises:
• Shoulder Press
• Pullovers
• Pulldowns
• Example preventative / corrective exercises:
  • Incline Shoulder Raise
  • Cable Row
  • Pectoralis Minor Stretch
  • Wall Lat Stretch

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Questions

1. **A winged scapula condition indicate a what**
   
   (a) A definite serratus anterior weakness (correct answer)
   
   (b) A definite serratus posterior weakness
   
   (c) A curvature of the spine
   
   (d) Ability to increase the number or pullovers that can be completed
   
   (e) All of the above

Protracted Shoulder Girdle

**Source:** http://www.exrx.net/ExInfo/Posture.html

**Concept:** Postural Muscle Groups

The shoulders are pulled forward. Medial border of the scapula may also protrude slightly from body. Increased risk of shoulder injury during shoulder transverse flexion and transverse adduction activities, specifically when elbow travels behind shoulder. Risk of shoulder injury is compounded with an infraspinatus weakness. Possible limited range of motion during retraction of the shoulder girdle. A protracted shoulder girdle may be accompanied by a winged scapula condition or transverse adduction / flexion inflexibility. The subscapularis and Pectoralis minor and clavicular & sternal heads of the pectoralis major muscles may be short. The trapezius (middle fibers) and particularly the rhomboids may be weak if the medial borders of the scapula also protrude slightly from body. Examples of affected exercises: Bench Press Chest Press Flies Example preventative / corrective exercises: Doorway Modified Chest Stretch Wall Shoulder Girdle Stretch Doorway Subscapularis Stretch Cable Row

Questions

1. **A protracted shoulder Girdle affects which of the following exercises**
   
   (a) Bench Press (correct answer)
   
   (b) swimming
   
   (c) jogging
   
   (d) Sprinting
   
   (e) All of the above
6.2 Think Aloud Usability Study

All participants using the Appollo Framework were asked to perform a think aloud usability study. Each user was asked to complete the following tasks within the specified time period. Validating the usability of the mobile information delivery interface is based on users being able to complete all tasks within the time frame provided.

6.2.1 Think Aloud Representative Tasks

Each participant will complete the following tasks:

<table>
<thead>
<tr>
<th>#</th>
<th>Task Description</th>
<th>Maximum Time For Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Register with Appollo - provide all registration data</td>
<td>60 seconds</td>
</tr>
<tr>
<td>2</td>
<td>Read through the Appollo marketing information</td>
<td>60 seconds</td>
</tr>
<tr>
<td>3</td>
<td>Select an Avatar</td>
<td>10 seconds</td>
</tr>
<tr>
<td>4</td>
<td>Select a quiz frequency</td>
<td>10 seconds</td>
</tr>
<tr>
<td>5</td>
<td>Select a learning package</td>
<td>10 seconds</td>
</tr>
<tr>
<td>6</td>
<td>Read a document and provide feedback</td>
<td>180 seconds</td>
</tr>
<tr>
<td>7</td>
<td>Select a confidence level</td>
<td>10 seconds</td>
</tr>
<tr>
<td>8</td>
<td>Read enough documents to trigger a quiz</td>
<td>Variable Length (180 seconds x Quiz Frequency)</td>
</tr>
<tr>
<td>9</td>
<td>Read a total of 10 documents and conduct at least 5 quizzes</td>
<td>Variable Length (180 seconds x Quiz Frequency)</td>
</tr>
<tr>
<td>10</td>
<td>Inspect the user model</td>
<td>180 seconds</td>
</tr>
<tr>
<td>11</td>
<td>Inspect the Avatar model</td>
<td>180 seconds</td>
</tr>
</tbody>
</table>

6.2.2 Usability Test Consent

The following form was used to ask for consent from the participants to provide information in the usability study.

Usability Test Consent Form

Please read and sign this form.
In this usability test:

• You will be asked to perform certain tasks on an iPhone.
• We will also conduct an interview with you.
• You will be asked to fill in a questionnaire.

Participation in this usability study is voluntary. All information will remain strictly confidential. The descriptions and findings may be used to help improve the Appollo iPhone app. However, at no time will your name or any other identification be used. You can withdraw your consent to the experiment and stop participation at any time.
6.2. Think Aloud Usability Study

If you have any questions after today, please contact Anthony Simonetta at 0400 877 003.
I have read and understood the information on this form and had all of my questions answered.

6.2.3 Questionnaire
The following questions were presented to each participant in the user study to capture qualitative data about their experience with Appollo.

1. On a scale of 1-5 how engaging was Appollo?
2. What was the point of the avatar?
3. Did you find Appollo challenging?
4. How was your score calculated?
5. How was your Avatar’s score calculated?

6.2.4 Interview
The following questions were asked of each participant after they had conducted the think aloud usability study.

1. Would you use Appollo again?
2. Were the snippets you read accessible?
3. Did you feel challenged by the Avatar?
Chapter 6. Appendix 1: Supporting Wellness Documents
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