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Dissertation

School of Computing & Information Engineering

Méabh Mackel | B00627325

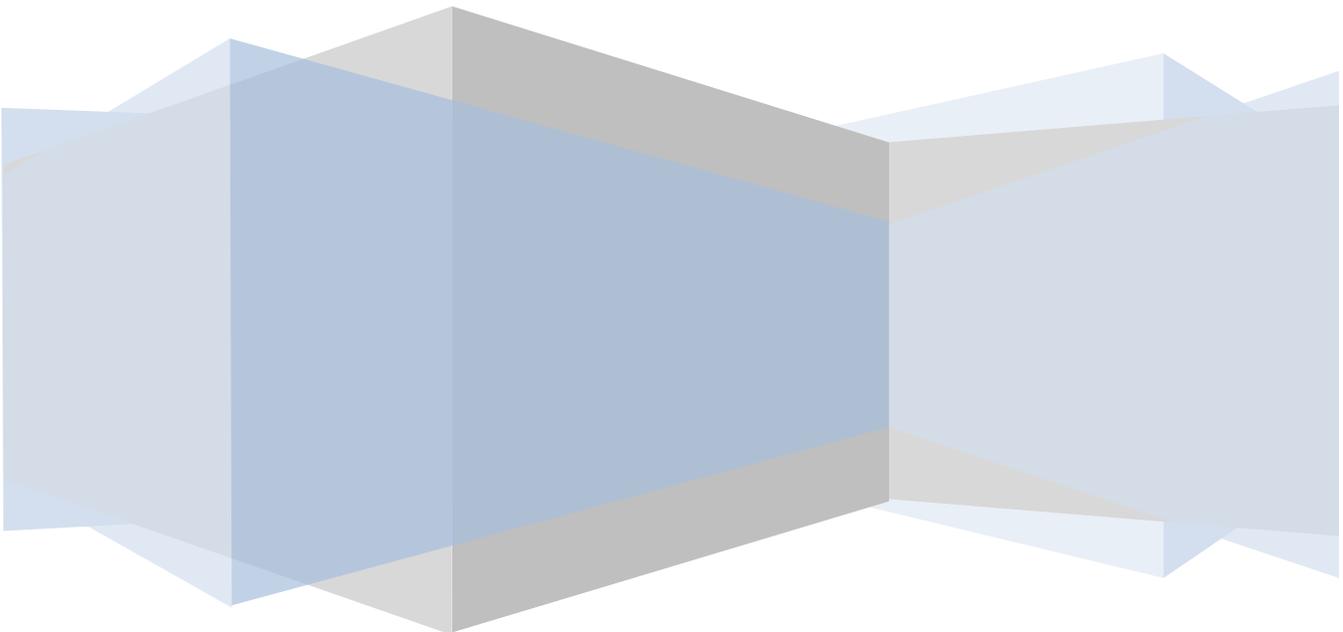
The Animated Gardener

A Region-Specific, Garden Planning Web Application

Supervisor: Ms Janet Alison

Second Marker: Dr Adrian Moore

Date: 30th September 2016



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1 ABSTRACT

The practice of growing one's own food is enjoying a resurgence at present and the number of resources available to the amateur gardener is increasing in line with the demand.

This dissertation discusses this phenomenon, in the context of the global recession. Financial, physical and mental health can all be positively impacted by 'growing your own', so the practice should be supported.

However, many books and applications assume a level of knowledge that the beginner gardener will not have, and the volume of information can be so vast it proves overwhelming. The majority of resources are targeted at either British or American users. Although these resources certainly contain some information useful to all gardeners, information on growing seasons, pests and which plants can be easily grown, will not be. Such applications often assume a significantly larger plot than is standard in other regions.

For those gardeners living in Ireland, including the exposed North West of the country, who want a software supported resource to assist with their learning, they must wade through these resources and attempt to reject what is not applicable.

The solution presented is a web application targeted primarily at beginner gardeners based in the aforementioned regions. The plants included are suitable for Irish climates. The user can input the specifics of their own garden including the sun distribution. They will be able to easily see what the sun requirements are of each plant, and will know whether the location is viable.

The application also features links to information on preserving produce and encouraging wildlife, which are often of interest to those who grown their own.

Although functional, the application is the essence of an idea that could be developed much further.

2 INTRODUCTION CHAPTER

2.1 INTRODUCTION

Gardening, in particular ‘growing your own’, has enjoyed a resurgence in recent years.

Locally, a plethora of publicly accessible community gardens have been established in the Derry and Strabane District Council in recent years, providing free and subsidised gardening classes for locals. This has not entirely satisfied the demand, however, as local gardening centres have also reported an increase in sales of seeds, plants and equipment related to vegetable gardening.

Many primary schools in Northern Ireland are proactively working to create a more sustainable society, by becoming ‘eco-schools’. The European-wide programme aims to make environmental awareness and action an intrinsic part of life. Amongst the benefits listed are empowerment for pupils, increased environmental awareness and improved surroundings (Eco Schools NI, n.d.).

This interest may be, in part, inspired by the global recession. During the first and second World Wars, vegetable, fruit and herb gardens, known as Victory Gardens, were planted in private residences and public parks in the United Kingdom, America, Germany, Australia and Canada. They were seen as a way to reduce pressure on food supply whilst simultaneously boosting morale. These gardens are again appearing in urban areas across the world. Clearly, survival is a strong motivator in many of these cases.

Germany has promoted urban gardening in the form of allotments, or Schrebergarten, since the 19th century (Stewart, 2013). Such gardens are seen as places to enjoy with family or friends, not solely as a source of food.

In 1976, a generation of city-dwelling Britons were inspired by ‘The Complete Guide to Self Sufficiency’, written that year by John Seymour, as well as by the popular sitcom of the decade, ‘The Good Life’ in the same theme. It offered people an escape from the pressures of modern city living and a return to the land (Bates, 2016).

Gardening is no longer seen as a weekend pastime of the suburban middle classes. There are many motivators and the contexts are varied. There are also many benefits.

It is a form of exercise and there is evidence that exercise can help the beneficiary lead a longer and happier life. It can reduce the risk of many chronic diseases, as well as boosting mood, sleep quality and stress levels (NHS, 2015). It is available to all age groups, and can be a good way for different generations to work together. There are many social benefits to gardening (Bord Bia, n.d.). Vegetable gardening in particular, can also help people become aware of what is in season and make better choices when shopping, further reducing their carbon footprint (NI Direct, 2014).

Alan Titchmarsh also points out that not only is growing something to eat practical, but that there is also a joy to be experienced through transforming a patch of land. Perhaps this is linked to the idea that gardening is inherently an investment in the future (Gander, 2016).

Unfortunately, despite the demand and the wide-ranging benefits to the participants, in areas where council-run allotments are available, waiting lists are extremely long. It has been estimated there are in the region of 86,000 people waiting for an allotment in the UK (Siegel, 2011). Ireland has, in recent years, begun to promote 'growing your own' much more, but many councils North and South do not offer allotments. In the Derry City and Strabane District Council area, a person can expect to wait up to 10 years for a plot.

However, a standard 250 square meter plot is not always necessary, and may be too much for the average beginner. A growing number of people are turning to their small gardens, and to the abundant patches of urban wasteland that scatter housing estates, in order to join the 'Grow Your Own' movement. These small spaces must be planned well in order to realise the best possible results.

There are currently a number of apps and web applications that assist in planning a garden. However, many of the landscaping products available are often targeted towards larger plots, ignoring the potential that smaller spaces offer. Others begin with the assumption that the gardener is already aware of concepts such as companion planting and the ideal location for specific plants.

Additionally, many of the applications on the market are designed for American or British users. Although some useful information can be gleaned from these apps, the information on growing seasons and pests can often be totally incompatible with the Northern Irish or Irish gardeners' experience. This can also be true of many blogs, websites and books. Many such applications can be expensive to purchase, or require an annual subscription, which is not feasible for many, particularly those in social housing.

2.2 PROBLEM STATEMENT

The recent resurgence in gardening and 'growing your own' has reached those in compact urban spaces.

The beginner gardener, with access to a small urban space, can often find themselves overwhelmed by the number of factors they must consider, or distracted by the volume of information aimed at users from other regions that they must disregard.

The solution is a cost effective, region-specific application which will present the enthusiastic amateur gardener with a canvas on which they can lay out and plan a vegetable garden.

It will allow the user to input measurements and specifics and will utilise drag and drop technology to plan the growing space. The application will also provide helpful tips.

The rich picture to represent this problem, developed in Phase 1 is attached as Appendix 1.

2.3 AIM

To develop a responsive, region-specific application, to assist the enthusiastic amateur gardener to plan a small urban vegetable garden.

2.4 OBJECTIVES

1. Carry out a review of applications on the market and evaluate their key features.

2. Develop a short questionnaire and administer to a Focus Group of key stakeholders.
3. Review findings and develop a list of functional and non-functional requirements.
4. Design a visually appealing user interface, that is clearly laid out, easy to navigate, containing relevant information with appropriate colour scheme, font selection and imagery.
5. Design and develop a prototype to ensure strong functionality and design in the finished product.
6. Test and evaluate the system.

2.5 SYSTEM REQUIREMENTS

This application was developed using existing software and hardware resources to achieve the aim and objectives outlined. The following tools were utilised:

- ASUS Notebook.
- Abyss Web Server, MySQL database and interpreters for scripts written in PHP.
- Programming languages: PHP, JavaScript, JQuery, HTML5 and CSS

2.6 DISSERTATION OUTLINE

Chapter 3: The Analysis Chapter provides an account of the investigation of the problem. It details the research on the benefits of 'Growing Your Own'. Five existing applications are reviewed, identifying their strengths and weaknesses. Findings are presented in individual Pros and Cons tables and a Summary Table.

Chapter 4: The Requirements Analysis Chapter identifies the requirements of the end-user of the proposed web based application. The requirements are established through research of the problem and solution, analysis of other applications on the market, and by using feedback obtained from interaction with the Focus Group.

Chapter 5: The Design Chapter outlines the guiding principles adhered to in the design of the website and the user interface. Choices on the navigation of the site, layout, colour scheme and

font selection are explained. The chapter also describes the software architecture, data definitions and algorithms utilised.

Chapter 6: The Implementation Chapter describes the process of implementing the solution. It presents the lessons learned from the initial prototype and how the system progressed from this point. Key aspects of functionality is also discussed.

Chapter 7: The Testing and Evaluation Chapter describes the approach to testing and the categories across which testing took place. It presents the results of the testing and evaluates the system in this context.

Chapter 8: The Conclusions Chapter concludes this dissertation. This chapter summarises and critically assesses the work as a whole, and discusses the evolution of the project, recommendations for further development and lessons learned.

3 ANALYSIS CHAPTER

3.1 INTRODUCTION

This chapter provides an account of the investigation of the problem. The chapter begins with a summary of the research carried out, which considers gardening in the context of a global recession and identifies the benefits of gardening and ‘growing your own’ to the individual and the wider community.

The research is followed by an analysis of the applications on the market, detailing their strengths and weaknesses. Screenshots are provided for all applications analysed, pros and cons are presented in individual tables, and a summary table compares all applications analysed. The chapter ends with a short summary.

3.2 RESEARCH

Research on the subject has been broadly categorised into three sections:

- A discussion on the concept of the ‘recession garden’ and its growing popularity across the globe.
- The benefits of ‘growing your own’ to the individual.
- The benefit to the wider community.

3.2.1 The Recession Garden and Urban Gardening

The Urban Dictionary describes ‘recession gardens’ as

“Backyard, urban gardens planted to squeeze every penny out of a food budget.”

These gardens are reminiscent of the Victory Gardens of the Second World War and, as asserted in the introduction, are appearing in areas of deprivation across Europe and further afield.

- In Greece, derelict land has been transformed into public allotments to alleviate the food pressure felt by families living in extreme poverty (Adler, 2012).

- A resident-led mobilisation in low income areas of Paris, resulted in the creation of an urban growing space (Allotment Resources, 2013).
- Food gardens make up 8% of all land in Havana.
- After the collapse of the Soviet Union left Cuba without the food and chemicals they had previously imported, Cubans faced starvation. The city quickly became a centre of organic urban farming and natural pest control (Clouse, 2014).

Although most people are not on the brink of starvation, the recession has affected communities across Britain and Ireland. Although Britain has long had a culture of allotments, Ireland has revelled in a wave of organisations promoting and supporting urban and community gardens.

The worldwide organisation, GIY International, came to Ireland in 2009 with the aim of building awareness and knowledge about food growing. Since then, the organisation has grown in size and has an annual festival, Grow Headquarters, as well as affiliated groups all over the country. Capital Growth, based in London also supports people to grow their own. They claim there are over 2000 affiliated community gardens in the city (Capital Growth, n.d.). In addition, urban and community gardens are now central to the work of many community groups in Northern Ireland.

Whether they are aware of it or not, these groups have their roots in Liz Christy's Guerrilla Gardening (GG) project in 1970s New York. She wanted to do something about the 'urban decay' that surrounded residents so the organisation voluntarily 'greened' areas by throwing 'seed bombs' into derelict lots and building community gardens (Green Guerillas, n.d.). There are now over 600 GG sponsored gardens in New York, where local residents can grow their own produce and enjoy the spaces together.

Today, many still see urban gardening as a radical act of protest. Richard Reynolds has become an inspiration to a new generation of gardeners through his illicit night-time gardening of urban spaces in his native London and across Europe (Richardson, 2012).

However, gardening is still mainstream activity. In 2010, the Royal Horticultural Society (RHS) in Britain ran a campaign encouraging British people to 'grow their own'. Hilary Benn, the then Environment Minister, urged the same, stating food security and easier access to organic food as

his reasons. Figures from 2010 indicate that more food was being grown in back gardens in Britain than had been for over a generation. B&Q reported a 27% increase in vegetable seed packets and a 40% increase in ready to plant vegetables.

In the same year, Michelle Obama instigated a similar campaign, to encourage Americans to grow fresh food for their families. She is the only First Lady to grow a kitchen garden since Eleanor Roosevelt's Victory Garden in 1943.

Whoever is doing it, and for whatever reasons, there is a clear link between the economic reality and the resurgence in interest.

3.2.2 The Benefit to the Individual

"To forget how to dig the earth and tend the soil is to forget ourselves."

Mohandes Karamchand Gandhi

There is a raft of evidence supporting the benefits of gardening to our physical, emotional, social and spiritual well-being. Gardening can provide relief from some medical conditions and prevent the onset of others. Scientific research is pointing to the benefits felt by people affected by asthmatic conditions, various forms of cancer, dementia, stress and depression, and obesity in adults and children (Growing Health, 2014).

Even in those not at risk of a health condition, gardening can result in overall higher levels of physical activity, thus helping the participant burn more calories, contributing to healthy weight management. The NHS claim that people who eat more fruit and vegetables are less likely to develop chronic conditions such as heart disease, stroke and some cancers (NHS, 2014). The evidence shows that those people who grow their own food eat considerably higher amounts of fruits and vegetables. As a result, they also benefit from the additional nutritional content (NHS, 2015). As food grown in the garden is usually picked fresher, not mass produced, and has no or little distance to travel, it can also contain higher in vitamins and minerals than the shop bought equivalent (Klein, 2007).

Perhaps unsurprisingly in today's fast-paced world, there is significant emphasis on gardening as a means of reducing and dealing with stress. The NHS website lists ten methods of reducing stress and gardening falls easily into five of those mentioned (NHS Choices, 2014). A scientific study run in the Netherlands instructed participants to carry out a stressful activity and monitored their stress levels afterwards. The participants were split into two groups who either read or gardened for thirty minutes after the stress inducing event. The study found those gardening had markedly reduced cortisol levels in comparison to those reading (Van Den Burg, 2010).

The RHS has stated it believes gardening should be formally taught as part of primary education and not as an extra-curricular activity, as it 'makes children happy' (BCC News, 2010).

It also has the potential to save money. American supplier, W. Atlee Burpee & Co, believes a £50.00 investment will yield a return of £1,250, or a ratio of 1:25. The National Gardening Association of America make a more conservative estimate, stating that a \$70 investment will yield \$600 of produce over a year. In Great British Pounds, this is roughly equivalent to a £50 and £420 respectively. Food stuffs and the cost of gardening materials may differ, but there is clearly still a significant potential financial gain.

It appears to be fairly clear that gardening, growing your own food and consuming it are positive experiences for people. However, the reasons for this are varied.

Some theories purport that human beings are hard wired to enjoy the natural environment. Others point to the enjoyment to be gained from nurturing and caring for something other than oneself, or to the satisfaction of growing the food required to nourish oneself. Interestingly, a current scientific theory has found that a specific strain of bacteria found in soil can actually induce the brain to create serotonin, low levels of which is linked with depression (The Economist, 2007). Others still, point to the social benefits for the participant (Bord Bia, n.d.).

3.2.3 The Benefit to the Community

Gardening may be considered a practice of previous generations by some, when people were in the main, more self-reliant. However, this means it provides an opportunity for inter-

generational engagement. Children can learn from their parents and grand-parents, and there are jobs suitable for every member of the family in the garden.

It can also give people an opportunity to meet their neighbours. Creating a beautiful environment outside can be another space to enjoy with friends and family. Equally, the excitement of sharing your produce can inspire a social occasion in itself.

In recent years, there has been a concerted effort by community groups in the Derry City and Strabane District Council area to identify and regenerate local wasteland areas. Such spaces, which traditionally attract anti-community behaviour are now being systematically transformed into communal gardens and vegetable plots. There is a view that urban gardens can be a means of tackling anti community behaviour, and the approach has been adopted in other areas also (Loughboro Echo, 2013).

This has had a wholly positive impact on the regions in question. Areas are better kept and more pleasant to live in and there is a marked reduction in anti-community activity. Groups have reported that neighbours spend more time together, sharing seeds, exchanging tips and commiserating about the weather. There is a greater sense of community and residents feel more relaxed living in the area.

Although anecdotal, these findings are backed up by scientific research. A UK study, which draws on eighteen years of data from over 10,000 participants, confirms that access to urban green space can be significantly beneficial to mental health. The impact is roughly equivalent to a third of the benefit that marriage can have on our long term health, and a tenth that employment can have (White, 2013).

Community gardening and allotments can be said to have a socially levelling effect on those who engage. In this setting, social standing is related to gardening skills and the willingness to share knowledge rather than occupation or income (Ferres, 2012).

The additional green spaces also undoubtedly have a positive impact on the local wildlife. Concern for and awareness of biodiversity is high amongst frequent gardeners (Ferres, 2012). This is a positive thing for the wider environment. Additionally, many allotment holders, and

many community groups in the Derry and Strabane areas, have expanded their remit beyond vegetable growing to include providing suitable homes for bees, hedgehogs and bats.

3.3 ANALYSIS OF SYSTEMS ON THE MARKET

In order to assess which features work best in gardening planning applications and which are not useful, an analysis of the applications on the market was required.

Five applications were analysed and are detailed in the subsections that follow. A screenshot of each included, the findings have been presented in individual Pros and Cons Tables, and a final Summary Table, is included to present the overall analysis.

3.3.1 Grow Veg Garden Planner

Grow Veg is a UK application that allows the user to design their garden using a drag and drop function. It allows the user to set their location and input specific garden size. When plants are dropped onto locations the application adjusts the number of plant for optimised growing and informs the user.

There is an appropriate range of fruit, vegetables and generic plants to choose from and there are over 200 garden objects that can also be selected. Guidance and plant information is available and there are also links to tutorials. Overall the application was easy to use and practical. Many online gardening websites use the model supplied by Grow Veg.

Figure 1 – Screenshot of Grow Veg Garden Application

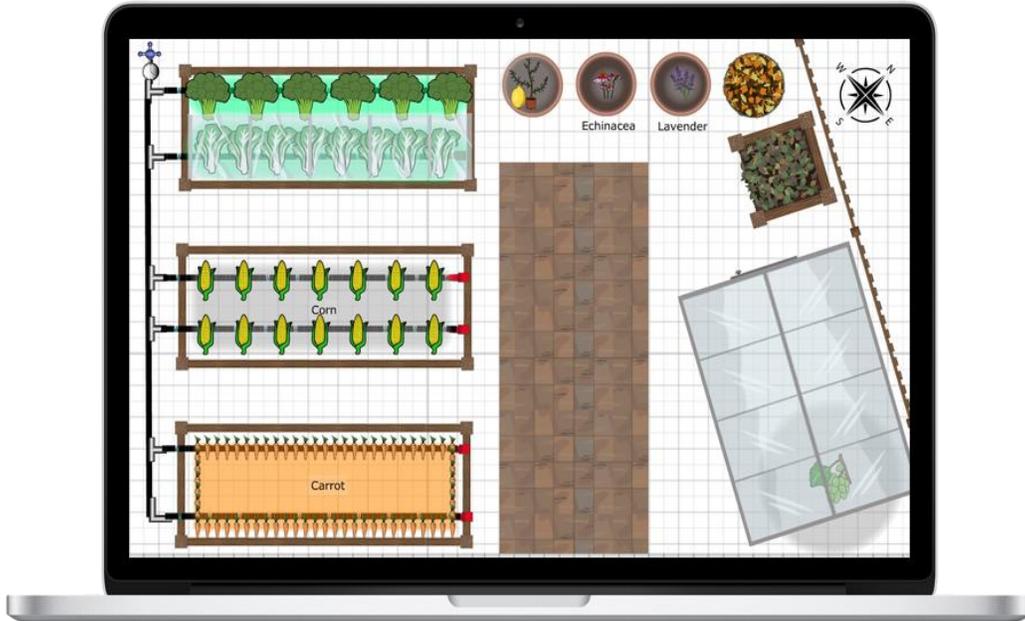


Table 1 – Grow Veg Garden Planner Pros and Cons Table

Feature	Pros	Cons
Localised Information	Included.	Some plants included that may not do well in this location. No additional info suggesting they will need extra sunlight or growing tunnel included. Novice gardener may be confused if plants don't do well.
Planting Guidance	Helpful guidance, application informed user how many plants could fit in each location. Crop rotation warnings and calendar update included for annual and perennial plants.	None.
Calendar	Included, auto update for harvesting and crop rotation.	None.
Drag & Drop	Very easy to use. Veg can be readjusted after dropping to alter	None.

	number of plants in area, or snap-to-fit items to plan.	
Offer other tips	A number of tutorials and videos included.	No tips section within app.
Cost	All features included.	Expensive, annual commitment.

3.3.2 Garden Minder

Garden Minder is suitable for both the iPhone and iPad. It does have a feature to design a vegetable plot, however it is aimed at the individual bed itself, rather than the space as a whole.

Users can design their own plan, or amend a pre-planned garden, but as the application is American, the sizes are significantly larger than the norm on this island, so this feature is less useful for local use. There is information on various plants and instructions to how to plant and harvest vegetables. However, the application does show plants that are not easily grown in this region.

Figure 2 – Screenshot of Garden Minder Application

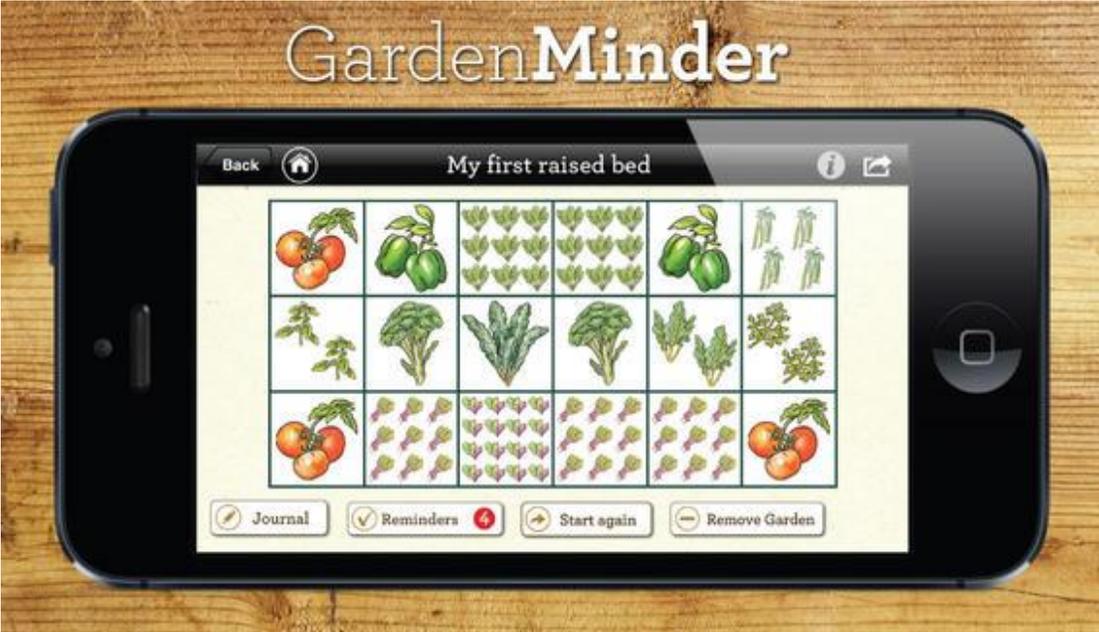


Table 2 - Garden Minder Pros and Cons Table

Feature	Pros	Cons
Localised Information	Feature included	Advertised as being localised information but application is actually America specific.
Planting Guidance	Guidance included, clear information, easy to follow. Very helpful for novice gardener.	Shows plants that may not be suitable locally.
Calendar	Included.	None.
Drag & Drop	Easy to use.	Garden templates are America specific.
Offer other tips	Tips offered.	Tips relate to pests such as deer which will not be relevant to local users.
Cost	Free.	None.

3.3.3 Garden Planner Pro

This application received positive feedback from online reviews and blogs. It was relatively easy to navigate, and although more cost effective than the Grow Veg Garden Planner application, it did not calculate and alert the user the number required for a space when dragging and dropping.

This is a common area of confusion for beginner gardeners. The user could, however, click on the plant and be taken to a Grow Guide which contained the required information. The application also featured a number of growing guides and a comprehensive plant catalogue.

A small, medium or large garden size could be selected, however the set sizes for even the small gardens were significantly larger than typical small gardens in this region and are not comparable to either social housing or allotment plots.

Figure 3 – Screenshot of Garden Planner Pro Application

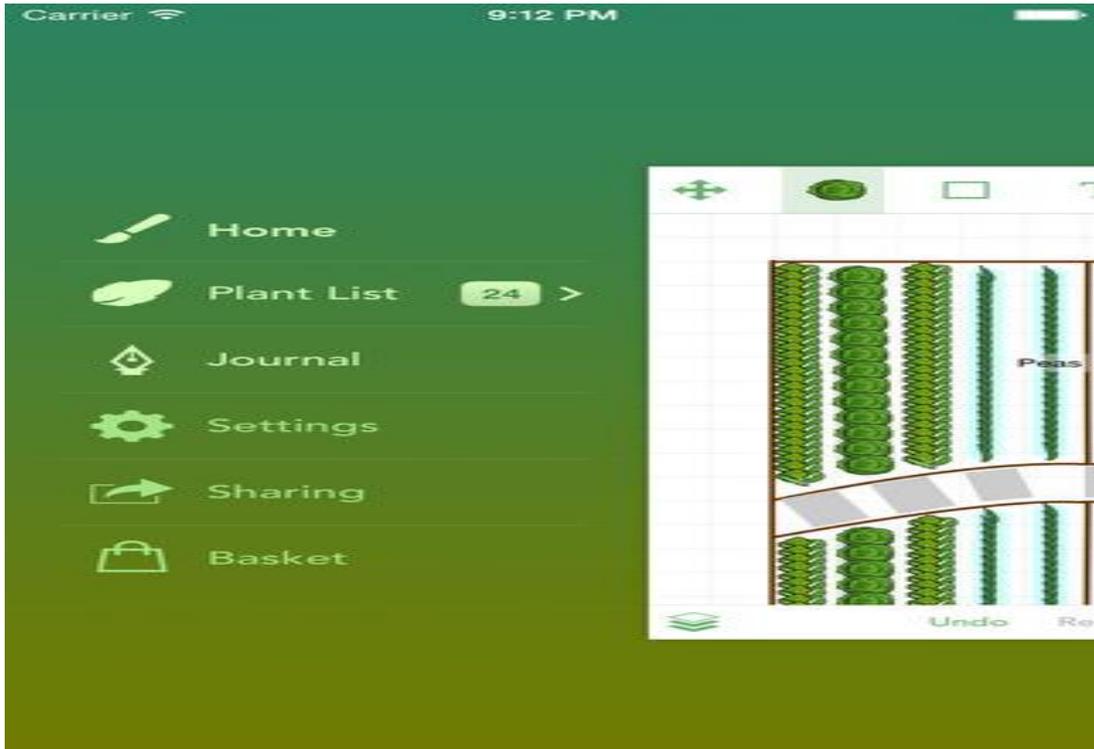


Table 3 – Garden Planner Pro Pros and Cons Table

Feature	Pros	Cons
Localised Information	None.	America specific. As a results, even when selecting small gardens, the size was significantly larger than the typical urban space in this location.
Planting Guidance	Features a lot of growing guides. Easy to understand information for beginner gardeners. Very comprehensive plant catalogue.	None.
Calendar	Included.	None.
Drag & Drop	Included.	Application could not inform user how many plants should go in highlighted area. Common

		mistake for the novice gardener is to underestimate the size of the mature plant. Less emphasis on actual measurements.
Offer other tips	Included.	None.
Cost	One off cost, reasonable.	None.

3.3.4 Garden Planner

The Garden Planner application was geared towards designing the space and did not contain any planting tips whatsoever. Neither could the user select specific plants, as with all other applications analysed.

In this regard it was less useful than the other apps. However, the landscaping aspect did contain a sketch facility which many users may find a more natural style of garden design. Objects could still be selected and dropped onto the scale image, but there was no range of plants, herbs or fruit bushes to choose from. Rather, a generic spikey plant, or bushy plant could be selected. This image did not auto-adjust to show the number of plants that could fit in a space, but the size could be manually readjusted.

Figure 4 – Screenshot of Garden Planner Application

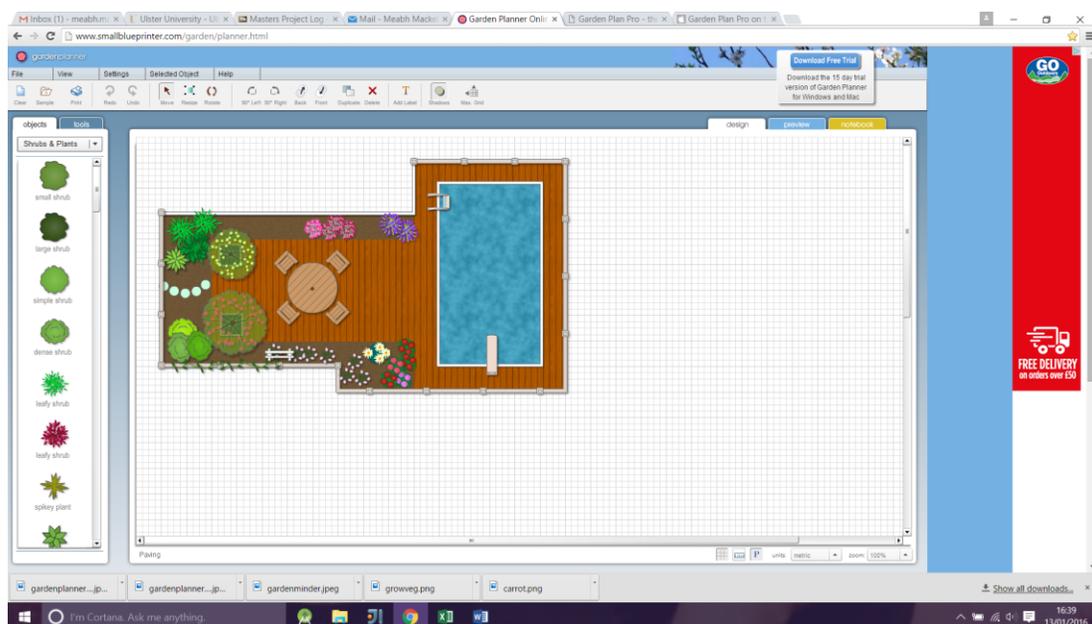


Table 4 – Garden Planner Pros and Cons Table

Feature	Pros	Cons
Localised Information	NA.	No growing guidance or plant info included.
Planting Guidance	None.	No growing guidance or plant info included.
Calendar	None.	No growing guidance or plant info included.
Drag & Drop	Included.	No focus on actual measurements, significant shortcoming. Plants could be readjusted but application could not advise how much space required. No detailed list of plants to drag and drop, just generic plants.
Offer other tips	None.	None.
Cost	One off cost.	Very high cost.

3.3.5 Plan a Garden

This app was not as easy to use as the other applications that were analysed. It did feature a facility to choose to plant a single plant, row or area of plants and the application did indicate how many plants went into the area, however this was not as intuitive as the Grow Veg Garden Planner.

As with the Garden Minder, a small, medium or large garden size could be selected, however the set sizes for even the small gardens were significantly larger than typical small gardens in this region. This is likely due to the fact that the application was American in origin. Although the space along the top was measured, there was no way for the user to adjust this to fit the measurements of their own garden.

Figure 5 – Screenshot of Plan a Garden Application

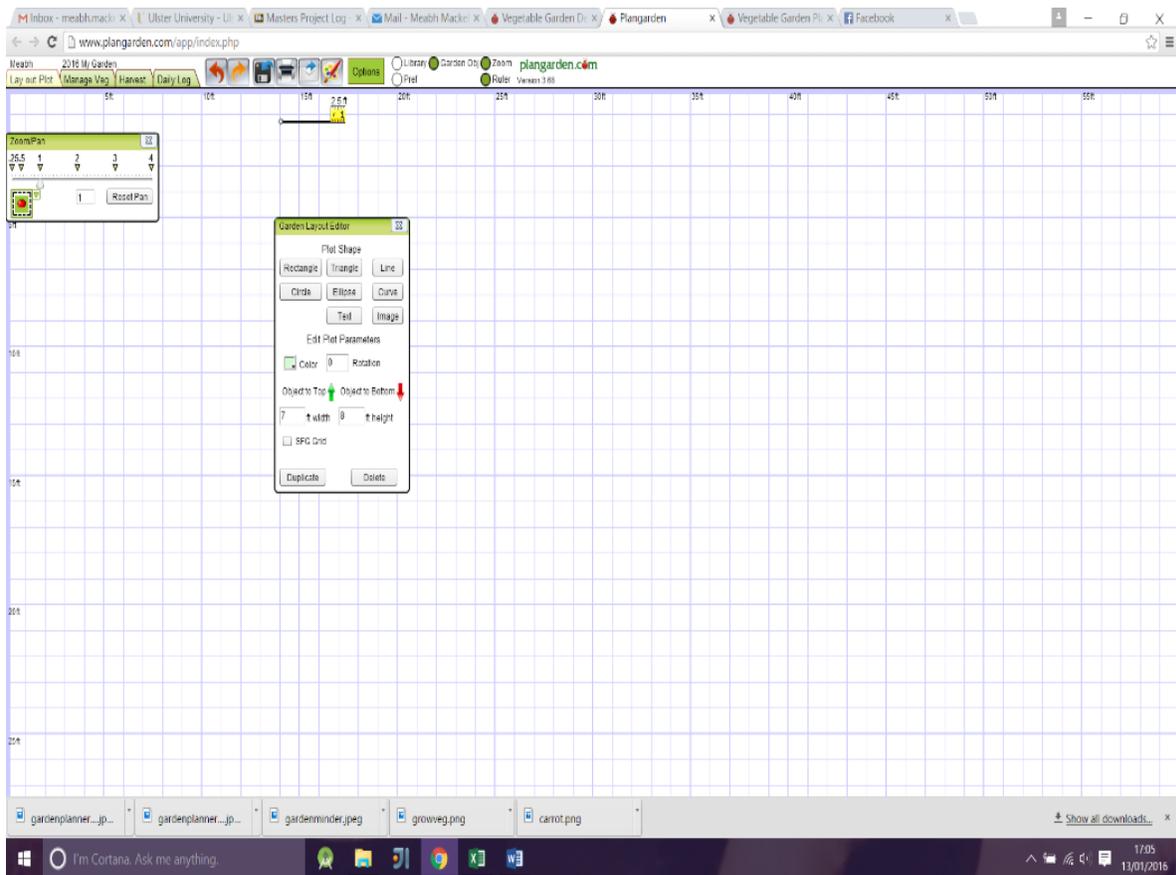


Table 5 – Plan a Garden Pros and Cons Table

Feature	Pros	Cons
Localised Information	None.	America specific.
Planting Guidance	Some.	Not as robust as other applications.
Calendar	Included.	Not as intuitive as other applications.

Drag & Drop	Included A single plant, row or area of plants could be dropped.	Not as intuitive or natural to use as other applications. No advice on how many plants should be planted. No emphasis on actual measurement. Significant shortcoming.
Offer other tips	None.	No other tips included.
Cost	One off cost.	High cost.

3.3.6 Summary of Analysis

In addition to the individual analysis of systems and the resulting pros and cons tables, systems were scored against each other and the findings are presented in the Table 6 which follows.

It is interesting to note that cost did not prove to be indicative of quality. None of the applications contained all the required features in a cost effective way.

The analysis provided useful insight into which features should be replicated in the planned application. The knowledge gained will allow the author to design and develop a cost effective, region-specific application to plan a small urban growing space.

Table 6 – Analysis of Systems Summary Table

Application	UI	Localised Info	Planting Guidance	Drag & Drop	Cost	Multiple Platforms	Marks	Notes
Grow Veg Garden Planner	✓✓	✓✓✓	✓✓	✓✓✓	£19 annually	PC, Mac, iPad & iPhone	10	Very popular. Annual cost is high.
Garden Minder	✓✓	✓	✓✓	✓✓	Free	iPad, iPhone	7	America only.
Garden Planner Pro	✓✓	✓✓	✓✓	✓✓	£5.99 one off cost	PC, Mac, iPad, iPhone	8	Positive reviews. Relatively easy to use.
Garden Planner	✓✓	x	x	✓✓✓	£24 one off cost	PC, Mac	5	No planting tips however good ability to plan space
Plan-a-Garden	✓	✓	✓	✓	£14 pounds one off charge	PC	4	Not as easy to use as other apps. America focused.

3.4 SUMMARY

This chapter has summarised some of the literature and resources on gardening and 'growing your own' reviewed by the author. The interest in 'growing your own' has been established, the variety of motivations were discussed, as well as the benefits to the participant and wider community. It has provided an in-depth analysis of the systems on the market, presenting their individual pros and cons and comparing the systems.

The information gathered from this research was integral to the process of designing a developing a system to assist the beginner gardener in planning an urban vegetable garden.

4 REQUIREMENTS AND ANALYSIS CHAPTER

4.1 INTRODUCTION

This chapter identifies the requirements of the user of the proposed web-based application. The requirements were established through research of the problem and solution, analysis of other applications on the market, and by using feedback obtained from interaction with the Focus Group.

The chapter includes a discussion on some key requirements of the application. There is an analysis of recommendations of the group with regards to the content, features and requirements, a summary table of the key findings of this research and user stories are presented.

The chapter concludes with the detailing of functional and non-functional requirements to be included in the applications design and a short summary.

4.2 REQUIREMENTS

After considerable research, analysis of the systems on the market, and engagement with the Focus Group, a web application was deemed to be the most appropriate platform.

A web application can better cope with the large volume of images and information required than an app. The application can also be launched from a number of devices. Further detail on the continuity of functionality is included in the Testing and Evaluation Chapter.

4.3 FOCUS GROUP ANALYSIS

A Focus Group Questionnaire, attached as Appendix 2, was drawn up using the information gleaned from the systems analysis of other applications on the market. It was sectioned into three parts and consisted of nine questions.

Introductory questions were designed to identify the skill-level of the user, ascertain how much time they ideally like to spend in their garden and how important they feel growing their own

produce is. This section also identified whether they felt a garden planning application would be useful to them, whether they would use one and how familiar they were with other applications on the market.

The second section surrounded the application content and structure. This section informed the users’ requirements of the application, and their preference on the structure of the application.

The third and final section identified the ideal presentation of the application, looking at font-family and colour scheme. Participants were also asked if they would assist with testing the application.

It was felt this size of questionnaire could obtain the optimum amount of information, without being excessively comprehensive. The Focus Group Questionnaire was distributed to individuals with an interest in gardening who agreed to form part of a Focus Group. Those who participated ranged in age, gender, social background and gardening skill.

A total of 10 questionnaires were distributed and all were completed fully. 60% of the respondents agreed to test the system, which proved instrumental in ensuring the final product is intuitive and useful.

4.4 SUMMARY OF FINDINGS

The findings from the questionnaire are summarised in Table 7 which follows.

Table 7 – Summary of Results from Focus Group Questionnaire

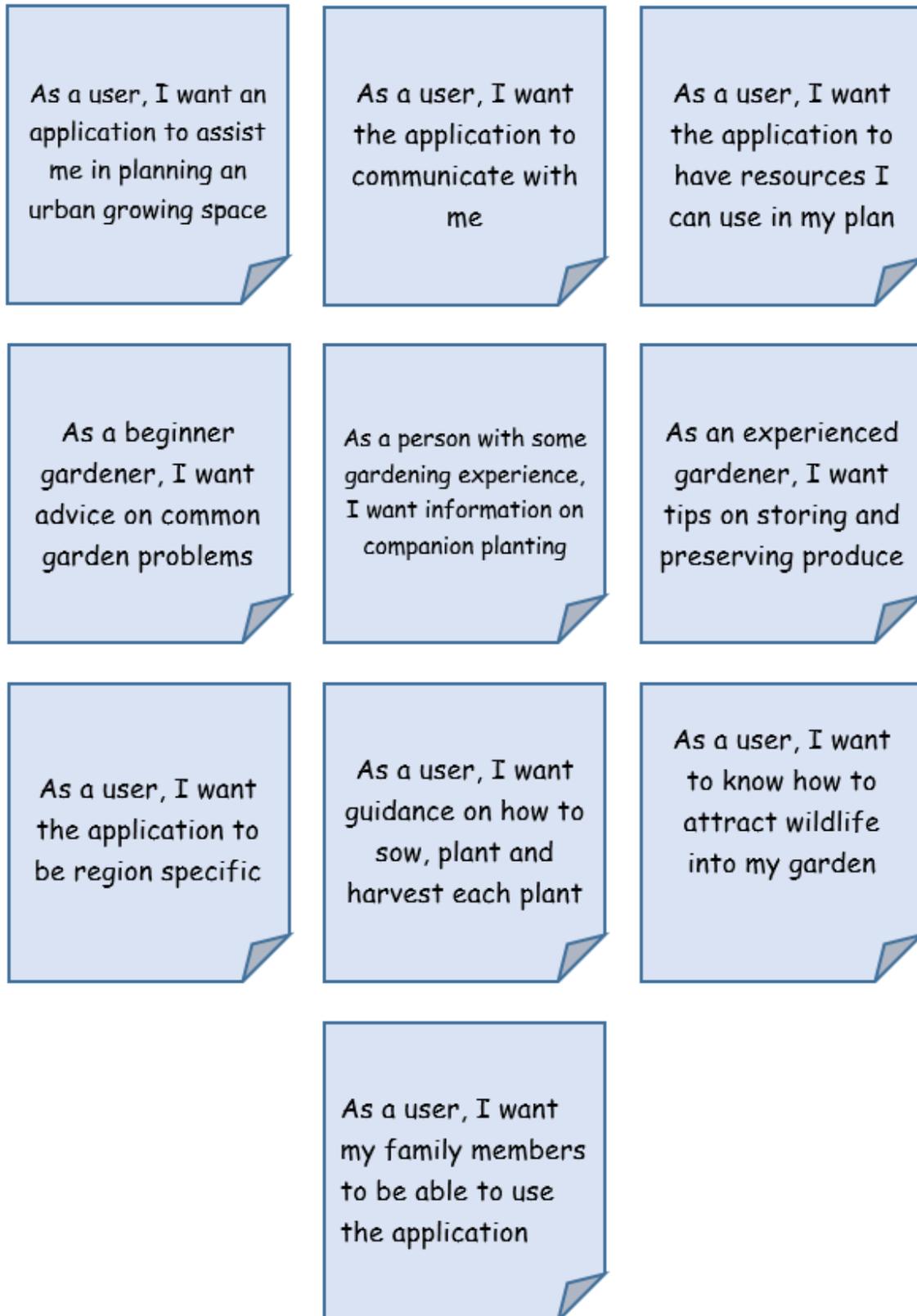
Question	Answer
1	60% of responses were from people with some gardening experience. 50% had some experience of planning a space. 50% spent time every week in their garden.
2	The majority of respondents agreed the application would be useful and said they would use it.

3	The majority of respondents had not used the competing applications.
4	<p>Virtually all the respondents wanted the proposed application to feature:</p> <ul style="list-style-type: none"> ▪ A drag and drop function for images. ▪ A personalised growing calendar. ▪ Planting advice. ▪ Information on companion planting. ▪ Tips for common problems and additional information on subjects such as storing produce and attracting wildlife.
5	Virtually all respondents wanted a personalised login, potential for multiple users, a saveable plan and an auto update of the applications calendar.
6	<p>The majority of applicants favoured a variation of Structure B</p> <pre> graph TD Home[Home] --> Plans[Plans] Home --> PlantCatalogue[Plant catalogue] Home --> TipsAdvice[Tips & Advice] Plans --> SavedPlans[Saved Plans] Plans --> NewPlan[New Plan] SavedPlans --> SelectedPlan[Selected Plan] NewPlan --> Freehand[Freehand] NewPlan --> GridTemplate[Grid template] PlantCatalogue --> Herbs[Herbs] PlantCatalogue --> Vegetables[Vegetables] PlantCatalogue --> Fruit[Fruit] Herbs --> HerbsPG[Planting Guidance] Herbs --> HerbsH[Harvesting] Vegetables --> VegPG[Planting Guidance] Vegetables --> VegH[Harvesting] Fruit --> FruitPG[Planting Guidance] Fruit --> FruitH[Harvesting] TipsAdvice --> Compost[Compost] TipsAdvice --> StoringPreserving[Storing & Preserving] TipsAdvice --> AttractingWildlife[Attracting Wildlife] </pre>
7	The majority of respondents favoured a sans serif font.
8	Equal numbers of participants favoured colour scheme A and colour scheme B. Further research was carried out by the developer to determine the most appropriate choice.

4.5 USER STORIES

The results of Focus Group Questionnaire were analysed and the findings presented as User Stories, which then formulated the functional requirements. Acknowledging these ensures clarity of the key requirements of the application. These are presented in Figure 6, which follows.

Figure 6 – User Stories



4.6 FUNCTIONAL REQUIREMENTS

- The application must be animated, in that it must be responsive to the user's actions and communicate with them.
- The application must allow the user to select images and drag and drop those images onto their plan.
- The application must be region specific.
- The application must have information on how to sow, plant and harvest each plant.
- The application must provide information on gardening best practice, such as companion planting.
- The application must provide information on common problems such as garden pests.
- The application must provide additional information on storing and preserving produce, attracting wildlife and composting.

4.7 NON-FUNCTIONAL REQUIREMENTS

- Usability: The website must allow users to browse easily for the information they require. It must function on a multitude of devices and internet browsers. The interface will be engaging and attractive.
- Efficiency: Webpage loading time should be kept to a minimum. Accessing data should be timely. Good SQL programming practice must be followed.
- Reliability: Good architectural design will minimise unexpected behaviour and further prevent errors.
- Portability: The website must run on a multitude of devices and platforms and behave as expected.
- Accessibility: All users must be able to view, navigate and interact with the application without obstruction. Text font and size represent legibility.

4.8 SUMMARY

This chapter has provided an analysis of the information obtained from engagement with the Focus Group. This has been used to determine the end user requirements for the application.

Requirements are in direct response to recommendations made by respondents of the Focus Group Questionnaire. These requirements, presented as User Stories, have been separated into Functional and Non-Functional Requirements which help to form the overall design of the website.

5 DESIGN CHAPTER

5.1 INTRODUCTION

This chapter is a significant section of this report. It outlines the guiding principles adhered to in the design of the website and the user interface, and details the many decisions made around design. It describes the software architecture, data definitions and algorithms utilised. A description of the scenarios considered and rejected in favour of the final solution is given, and a rationale for these decisions provided. Screenshots have been included where it is beneficial for clarity.

5.2 DESIGN METHODOLOGY

A key benefit of a web based application is that it can be displayed on a variety of devices. However, each device may have a different range of features and functions, for example screen size, or touch screen capability. It is therefore sensible to design an application that retains its key features regardless of the device from which it is accessed.

There are a number of other key points that must be considered in designing the application. User Interface design is a branch of Human Computer Interaction. Its aim is to anticipate and meet the needs of the user. (Information, School of, 2015) The user's experience directly affects whether they will use the application again. A badly designed user interface can mean a negative experience for the user, reducing the probability that they will return.

Schneiderman, in his Eight Golden Rules of Interface Design, specified the following guiding principles:

- The design will be consistent: It should be simple and use common elements and common patterns in language.
- It will cater to universal usability: The page layout will be clear, uncluttered and will follow universal templates where appropriate, for instance in the garden design or Q&A sections.

- Informative Feedback: For every user action there will be system feedback, commensurate with the level of action.
- Design dialog to yield closure: Sequences of actions will be organised into groups with a beginning, middle and end to give the user a sense of accomplishment when an activity has been completed.
- It will prevent errors: Where the user must enter details the design will ensure information is not entered in the wrong format, such as characters where a number should be entered.
- It will permit reversal of action and avoid short term memory load: (Schneiderman, n.d.) Navigation between screens, and within screens will be clear to avoid frustration on the part of the user.
- Support internal locus of control: Users desire that they are in control of their interface and that it is responding to their actions.
- Prevent overload of memory: Human's limited short term memory capacity requires that users should not be expected to remember information from a previous page and input it on the next page.

Generally, web-based applications, as opposed to websites, require a higher level of understanding of the system on the part of the user as they use the application to perform a task on an ongoing basis. This requires an understanding of who the user is. As this application is targeting users who will have varying degrees of IT literacy, it is crucial the design meets the level of the most novice of users. A good system is intuitive, enabling the user to learn the system as fast as possible (Jovanovic, 2010).

Website design must also consider accessibility. Accessibility is about ensuring people with disabilities, including aged-related impairments, have equal access to the web. The W3 Initiative has summarised accessibility into four requirements:

1. Perceivable - Information and user interface components must be presentable to users in ways they can perceive.

2. Operable - User interface components and navigation must be operable. This means that users must be able to operate the interface (the interface cannot require interaction that a user cannot perform).
3. Understandable - Information and the operation of user interface must be understandable.
4. Robust - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

These four requirements were adhered to, as were Schneiderman's Eight Golden Rules, to ensure the web application catered sufficiently to the user.

5.3 NAVIGATION

Clear navigation is critical to ensure user buy-in to the application. As a general rule, the navigation structure was deliberately simple and consistent, to ensure the user can easily find their way around the site (Gust, n.d.).

An early step in the navigation design was the production of detailed storyboards, attached as Appendix 3. Storyboards serve three main purposes (Washington State University, 2006).

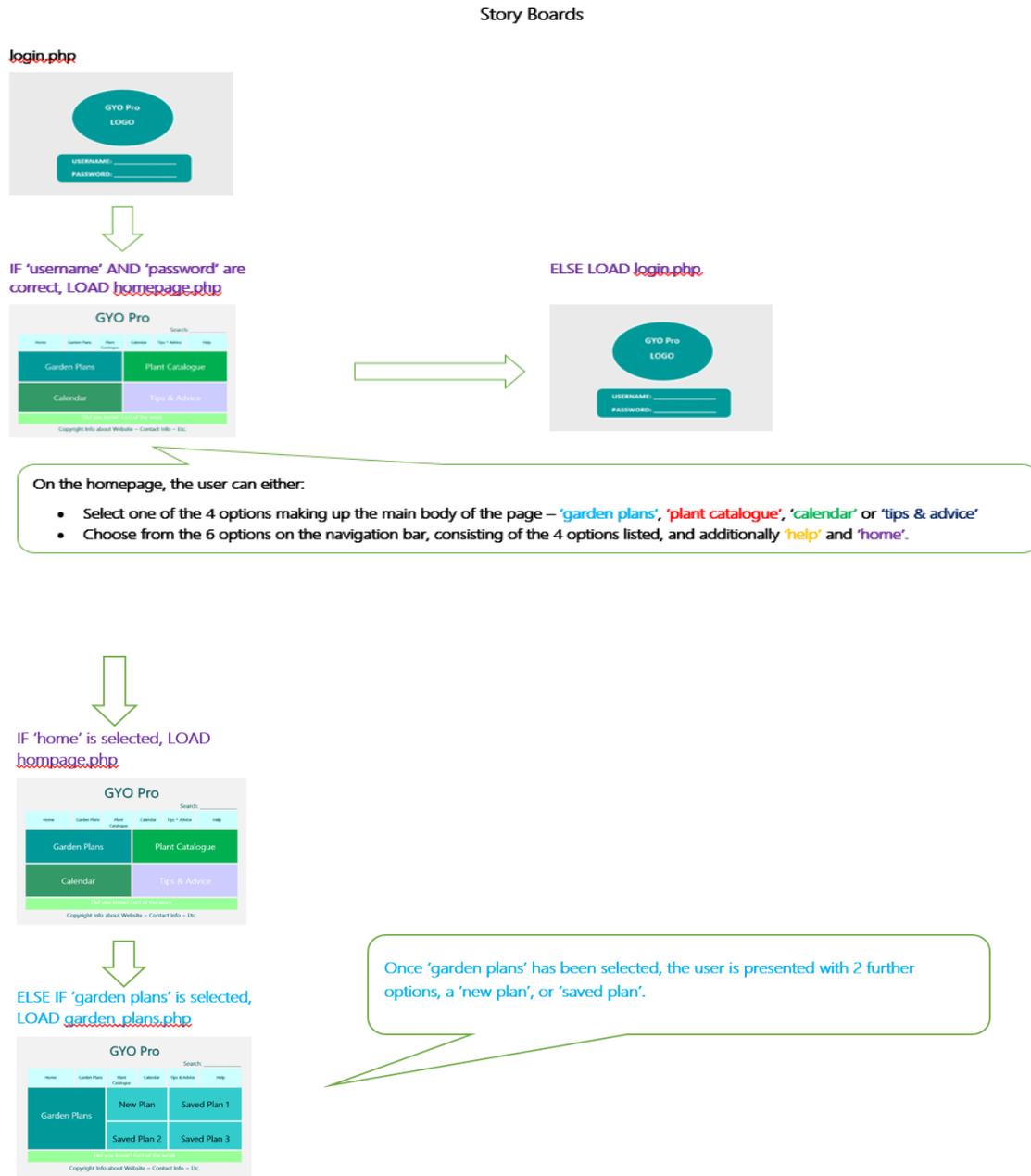
- Outline of the design.
- Defines the elements that need to go on each page.
- Shows the navigational architecture and information flow.

Several drafts were produced to ensure every facet of the site had been envisioned and the necessary algorithms considered.

The storyboards are included in full as Appendix 4 at the end of this dissertation, but Figure 7 which follows, presents a screenshot which outlines the basic outline of design, what elements are on each screen, and the pseudocode. The login page, home page and the garden plans page are all presented.

As can be seen, a basic mock-up of each screen was drawn up. This format is known as a Presentation Storyboard, and provides a visual representation of the site and solidifies the design model (Washington State University, 2006).

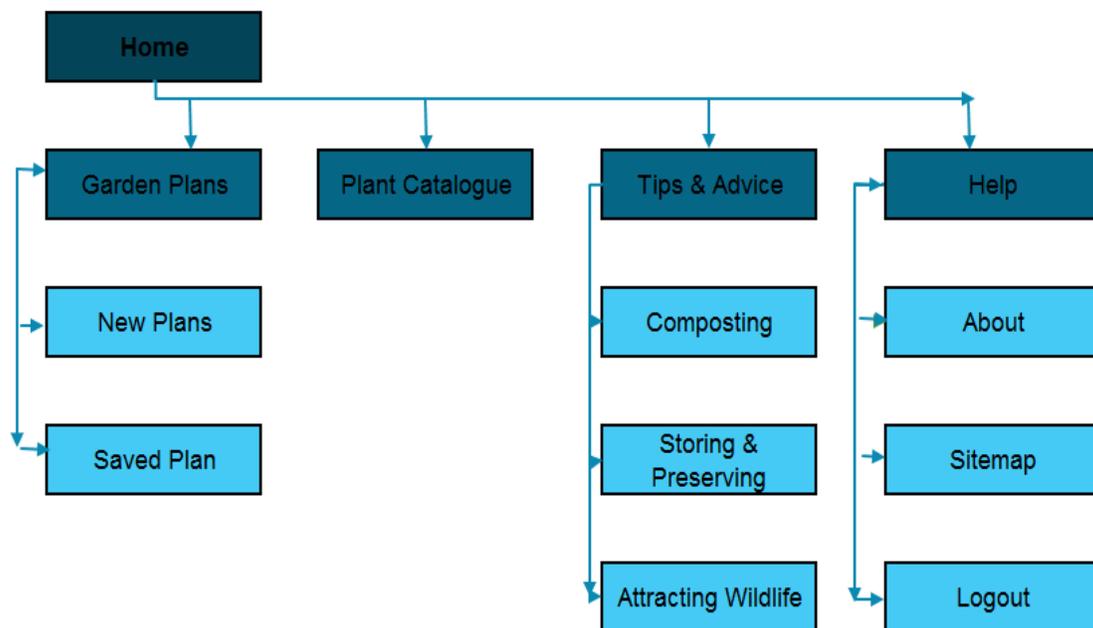
Figure 7 – Storyboards and Algorithms





Entwined with the process of drafting the storyboards, was the production of a Site Map, Appendix 4. Figure 8 which follows, presents each option that can be selected from each page of the website. The levels are differentiated using varying shades of blue.

Figure 8 – Site Map of the GYO Pro



The sitemap was designed to allow the user to get to any part of the application within three clicks. For example, if the user wants to get from the 'Home Page' to 'Site Map', they can take the route as shown in Figure 9.

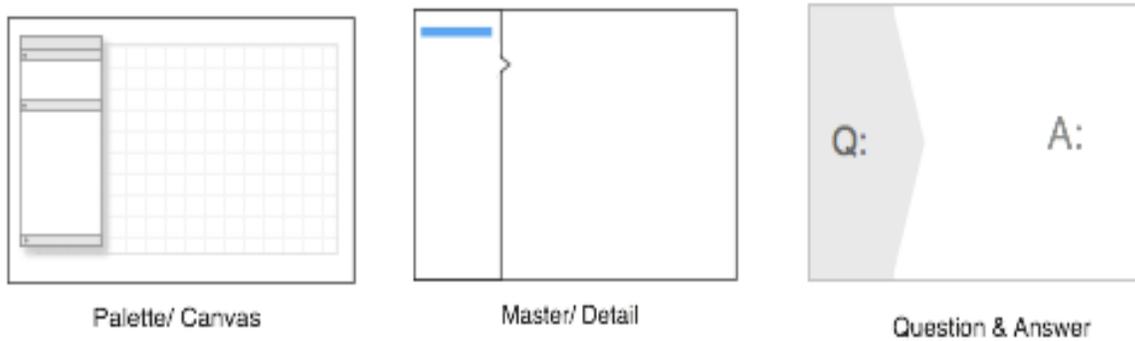
Figure 9 – Three Click Navigation



A number of additional factors helped to ensure the desired ease of navigation:

- A navigation bar was included, with drop down menus featuring text only links.
- This bar was present on every page of the site.
- Commonly found screen patterns were replicated, as research suggests that even a novice user will have an understanding of a common pattern (Figure 10).

Figure 10 - Common screen patterns



5.4 APPLICATION NAME & LOGO

Research into appropriate names was carried out early in the process. The developer liaised with members of the Focus Group individually but no viable suggestions came out of this process. The developer initially followed the logic of specifying in the name that the application is aimed at Irish climates, or North West climates. However, the combinations were not deemed concise enough to be practical. The name, GYO Pro, was finally selected because it rhymes and as such, is potentially more memorable to users.

Substantial time was invested trying to integrate the name and logo into one icon. The figure which follows represents a variation of what was explored. It was intended to make up the 'Y' in GYO, while also being appropriately suggestive of growth and gardens.

Figure 11 – Draft of Logo



Although the developer felt the essence of the idea had merit, the execution was lacking. A cleaner, more modern approach was adopted, consisting of the GYO Pro name in the chosen font and colour scheme, and a small watering can icon, shown below.

Figure 12 – Final Logo



5.5 COLOUR

Colour is an important aspect of design, as colours can have unconscious associations for people. As a result, they can vary in appropriateness for different settings. Investigation into the subject identified that green is unconsciously associated by many people with nature and energy (BBC Homes, n.d.). As such, it was deemed to be the most appropriate colour for a garden planning application. However, incorrectly used it has been suggested to provoke boredom, so it was decided green would be perceived best by the user if presented with another colour. Blue, yellow and pink all had the appropriate associations so they were presented to the Focus Group as options (Colour Affects, n.d.).

Initial mock-ups of the colour scheme of the homepage were produced for the Focus Group Questionnaire, which were designed to be indicative of the possible layout and to explore colour options. These are represented in Figure 13.

Figure 13 - Screenshot of Colour Scheme Mock-Ups



Although these initial mock-ups were useful in the preliminary stages, further work on the layout was considered a priority by the developer. The Focus Group selected both the green / blue, and green / pink options in equal numbers. Continued attention to this matter resulted in a variation of the green / blue scheme being adopted that is suggestive of scenes from nature, yet with a crisp, modern appeal. This is illustrated in Figure 14.

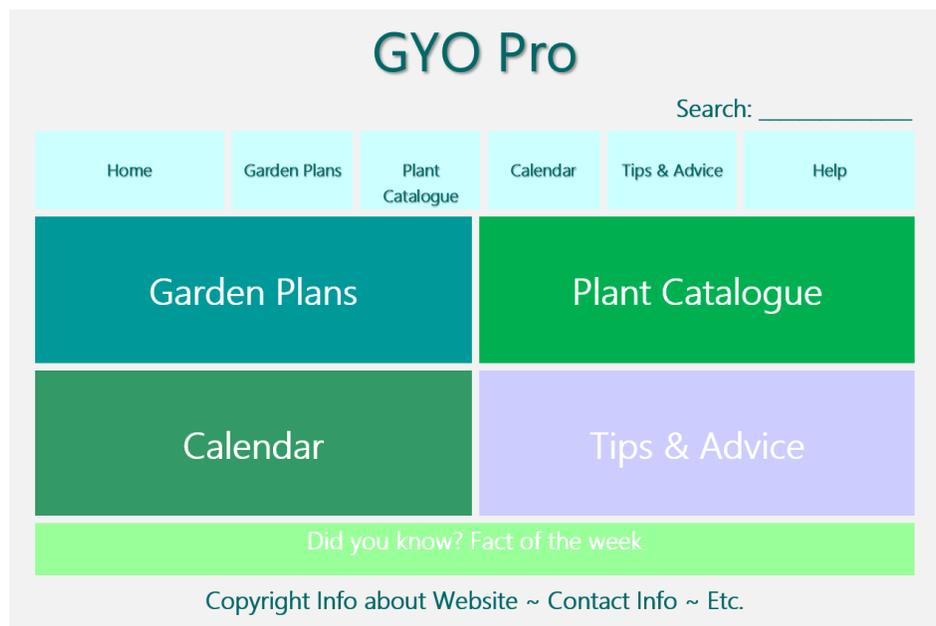
Figure 14 - Final Selected Colour Scheme



5.6 LAYOUT

Research of other websites carried out led the developer to the conclusion that the layout should be clear and uncluttered and modern in style. After researching a number of gardening websites, a mock-up of each page, as shown in Figure 15, was produced as a working model. The design was refined as the project progressed.

Figure 15 – Screenshot of the Draft Home Page Layout



The navigation bar present on the home page is in the same location and the options are in the same order on every screen. The logo and application name are combined and displayed top left of every screen. This logo is the home button. Legal information and contact details were included at the bottom on each page. The home page consisted of a loop of appropriate images and relevant quotes.

Each menu option on the home page is equally weighted. Options are highlighted when the user hovers over them for clarity.

5.7 FONT

A sans-serif font, meaning a font that does not contain the small finishing strokes on the end of characters, was selected as most appropriate by the Focus Group. It has been suggested by some studies that sans-serif may be more suited to being digitised as well as offering greater legibility in smaller fonts (Poole, 2008). This makes it an ideal choice for a web based application.

Legibility is also important to ensure ease of use for IT novices and accessibility for those with disabilities that impair their ability to use computers. A generic sans-serif font was therefore selected, as it is readable, appropriate for the application and presents uniformly across multiple devices and browsers.

5.8 ARCHITECTURAL DESIGN

The architecture of the application consists of a number of building blocks which combine to produce the final product. The sub-sections which follow, outline these building blocks in the context of this project.

5.8.1 Client / Server Relationship

In order to display a webpage, a browser is required. The Figure 16 which is taken from Code School's Front End Foundations course, illustrates the relationship between browser and webpage.

Figure 16 – Webpage-Browser-Device Relationship



The URL is made up of three sections; a protocol, a server and a file that's being requested. A request is sent to the server, and the server looks for that file.

The webpages retrieved are made up of HTML5, CSS, PHP and JavaScript. The server returns the file to the browser and the browser then displays it.

5.8.2 Abyss Web Server

Abyss Web Server is available on a number of operating systems. It is free to use, aims to be fully http compliant and its design goals are speed, low resource usage and portability. For these reasons it was chosen as the project's server.

5.8.3 HTML5 & CSS

HTML, or Hyper Text Markup Language, is the language of webpages. 'Hyper Text' indicates that it has the ability to overcome the constraints of written text, as it is interactive. 'Markup' is a way to specify attributes to the page, like font size and links to other webpages. The most up to date version at the time of this project was HTML5, so this was utilised to build to the website.

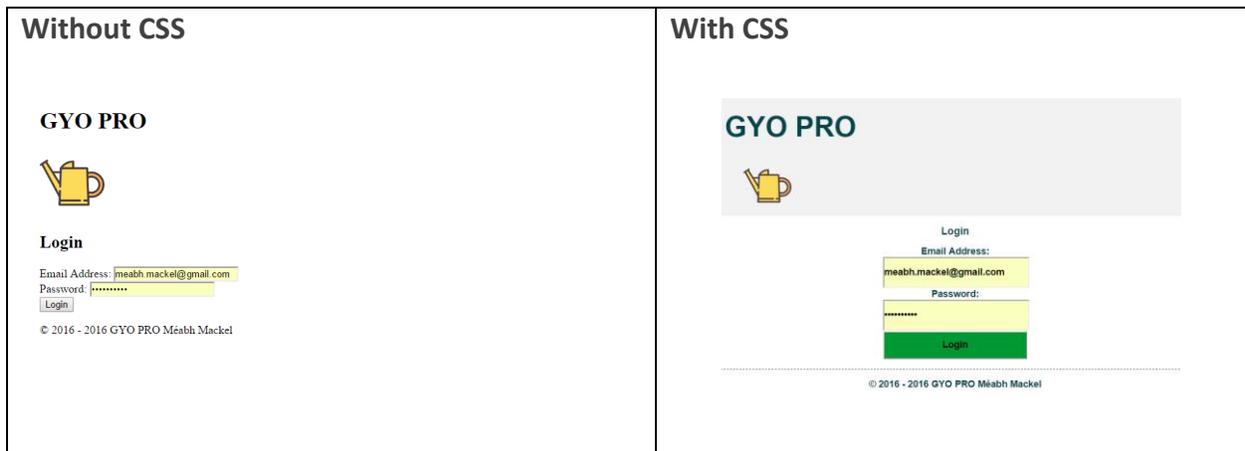
HTML does not determine how the page looks, merely how it is structured, so it is typically used in conjunction with Cascading Style Sheets (CSS). CSS code is used to change the appearance of HTML, such as the colour and level of padding around text boxes.

It is also crucial in ensuring functionality across multiple devices.

The Figure 17 below, taken from the login page of the site, illustrates the result of using CSS in conjunction with HTML.

The size and positioning of text, text boxes and images are altered to make a more usable, attractive interface.

Figure 17 – HTML Before & After CSS



HTML5 and CSS were thus used in conjunction to create the web application, in line with the decisions made on navigation, colour scheme, layout and font detailed in sections that precede.

5.8.4 PHP

PHP or Hypertext Preprocessor is a powerful language, yet makes a suitable beginner's first server-side language. The language runs on most Operating Systems, is compatible with most servers and supports a wide range of databases. All this made it an ideal selection for the project.

The main benefit of PHP is that it allows the developer to include dynamic content in webpages that cannot be achieved by HTML alone. Code is executed on the server and returned to the browser as plain HTML. This allows webpages to store their content in databases rather than having to maintain large volumes of pages. This was particularly useful in the case of the GYO Pro site because of the level of content.

5.8.5 MySQL

MySQL is and an open source relational database management system and is commonly used with PHP. It allows the developer to access and manipulate databases and their content. Queries are used to retrieve data from the database or update the content. Figure 18 shows the 4 tables in the site_db database, presented in the MySQL Command Line.

Figure 18 – Screenshot of MySQL Command Line Environment

```
MySQL 5.7 Command Line Client
Enter password: *****
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 24
Server version: 5.7.13-log MySQL Community Server (GPL)

Copyright (c) 2000, 2016, Oracle and/or its affiliates. All rights reserved.

Oracle is a registered trademark of Oracle Corporation and/or its
affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

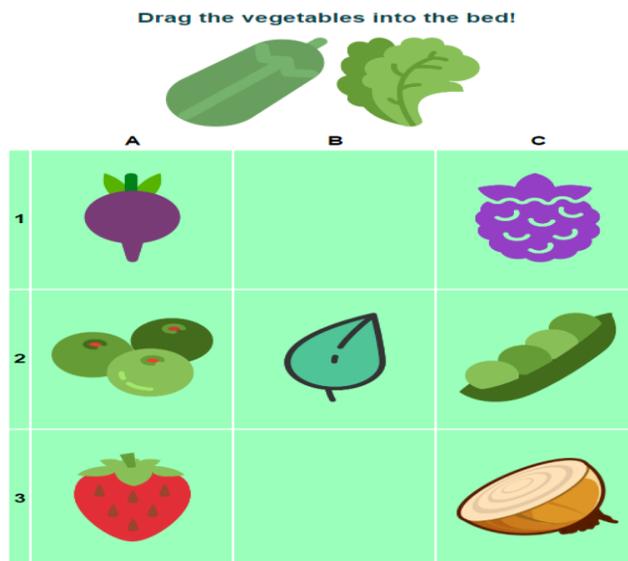
mysql> USE site_db ;
Database changed
mysql> SHOW TABLES ;
+-----+
| Tables_in_site_db |
+-----+
| garden_plans      |
| plants            |
| plants_in_garden  |
| users             |
+-----+
4 rows in set (0.02 sec)
```

In the application, MySQL facilitated the retrieval of information such as the user details, information on each plant, and the details of garden plans.

5.8.6 JavaScript & jQuery

JavaScript is considered one of the three languages that are essential for web development, with HTML and CSS being the other two. It is used to control and manipulate data on the client side, commonly interactive content. jQuery is a fast and concise JavaScript library. It supports the drag and drop function, a key functionality of the site, as shown in Figure 19 below.

Figure 19 – Drag & Drop Functionality



5.8.7 Database Design

Database design is crucial to the integrity of the application, and as such was considered a priority by the developer. Therefore, an initial plan of the database tables and their relationships was drawn up before the Databases module had begun, and was submitted with the initial Analysis Report, however this developed with the project.

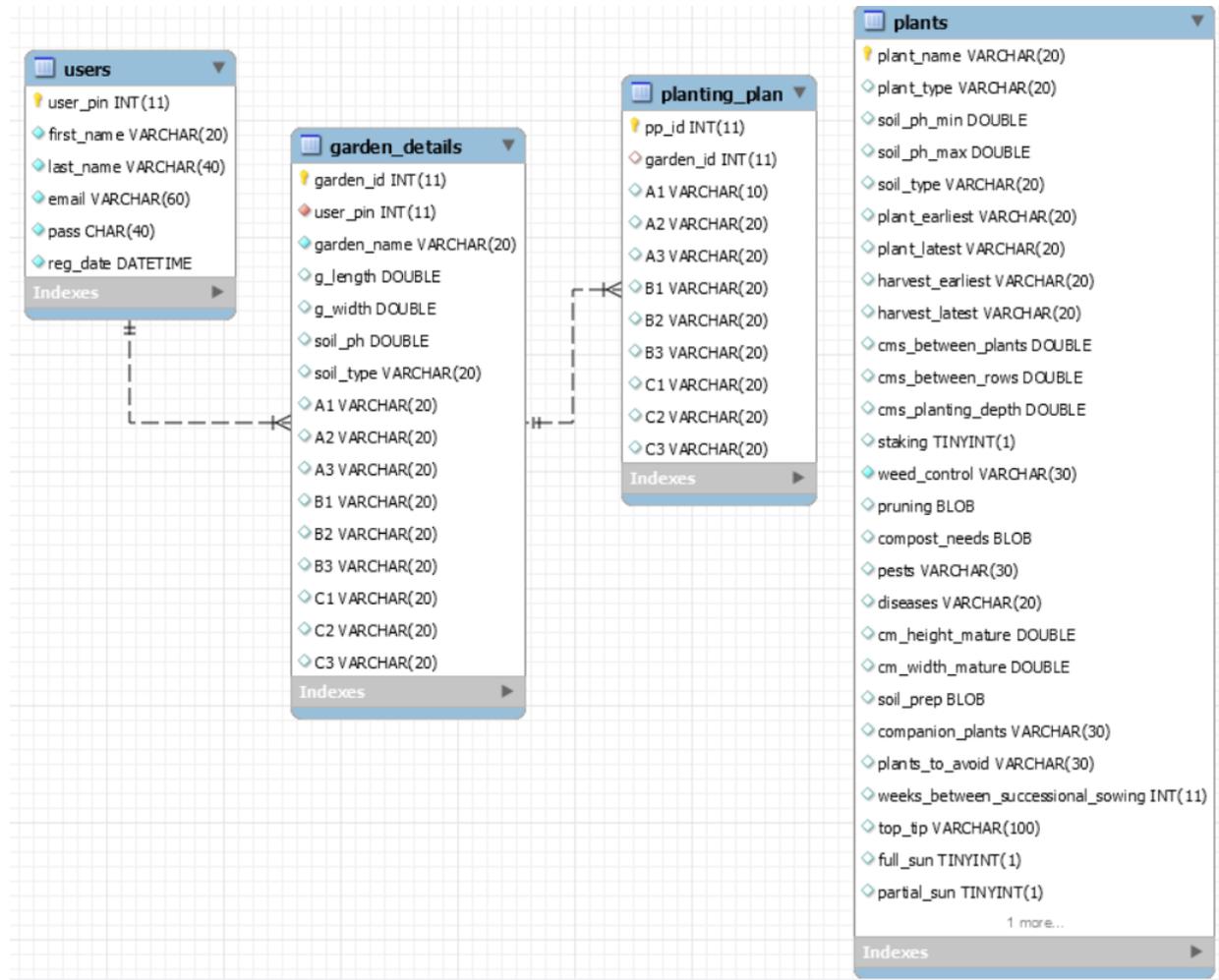
The structure for the application was based on a relational database methodology which defines a set of interconnected relations, or tables, for organising and storing data. Each table has a unique identifying name, and each attribute, or column heading, also has a unique name. Each table was assigned a primary key, which was used to uniquely identify the information within each tuple, or row, in the table. The primary key for each table was unique and not null, to ensure that there were no duplicate values. Tables were also assigned a foreign key which matched the primary key of another table, thereby connecting tables within the database.

The database consisted of four tables, 3 of which were connected. The plants table was not connected to the others.

- The 'user' table stores basic information on each user, specifically a user_pin and name, as well as email and password for login purposes.
- The 'garden_details' table stores a garden_id, name and measurements of the plot and soil_type. The light distribution was recorded and stored by dividing the plot into 9 x equally sized squares (A1 to C3), each of which stored a varchar value of full sun, partial sun, or no sun. The table is linked with the 'user' table in a 1:N relationship via its foreign key, user_pin*.
- The 'planting_plan' table was created to store where each plant is located in each planting plan. This is stored using a pp_id and again, an attribute for every cell on the grid (A1 to C3). It was connected to the 'garden_details' table in a 1:N relationship via its primary key, garden_id*. This table was not used and but was kept for future development.
- The 'plants' table has the highest number of attributes. It stores a plant_name, and multiple growing conditions, growing instructions and the potential measurements of the growing plant. This level of detail will facilitate further development of the application.

The tables and their attributes are detailed in Figure 20 which follows.

Figure 20 – Database Design



5.9 SUMMARY

The design chapter has outlined the methodology that informed the developer’s choices, the choices made in designing the GYO Pro application. In addition, it has described the architecture that supports the application, the building blocks of the site and how this software interacts together. The database that supports the application has been described and screenshots provided. The decisions made in this chapter formed an essential blue print for the developer to follow when coding.

6 IMPLEMENTATION

6.1 INTRODUCTION

This chapter describes the approach taken in developing the GYO Pro application. It will discuss the lessons learned from the initial prototype and how the system progressed from this point. The chapter will also detail the tools and new technology that was utilised in the implementation process.

The chapter will present the key functionalities of the system, significant aspects of the code, and the discuss algorithms that form the basis of the system.

6.2 IMPLEMENTATION PROCESS

The developer decided early in the process to loosely follow an agile style methodology because the approach is popular in industry. Tasks were broken into smaller sub-tasks in an attempt to allow for easy adaptation to change. Targets were set and, for the most part, easily achieved by working in this manner.

6.3 IMPLEMENTATION PLATFORM

The application was developed using HTML5, CSS, PHP, MySQL and JQuery. The developer had no knowledge or experience of these languages before embarking on the project, nor of how they interact. Numerous online courses, tutorials and textbooks ensured the necessary skills were developed in order to best employ the languages.

A range of implementation WYSIWYG (What You See Is What You Get) platforms were considered as environments to combine these languages. The developer investigated both Dreamweaver and Blue Griffon as possible options before selecting Dreamweaver. Although the split-screen functionality was useful, overall the environment contained so much pre-written, unused code that it was very difficult to amend any templates. After a number of weeks Dreamweaver was rejected in favour of Notepad++ the plain text editor. The following were also utilised:

- WAMP Server
- MySQL Workbench.

Software was implemented on an Asus Notebook PC SKU Intel Core i5 - 5200U, 2.2 GHz, 8Gb RAM, 64-bit Windows 10 OS with a 15.6inch display screen.

6.3.1 Database Implementation

SQL code to create the tables and add constraints was written first and saved in Notepad++ as this allowed for easy amendment if errors were made. It was then entered into MySQL Command Line. The figure which follows illustrate the code as initially written in the plain text editor.

Figure 21 – MySQL Code

```
1 CREATE TABLE IF NOT EXISTS users (  
2  
3 user_pin INT NOT NULL ,  
4 first_name VARCHAR(20) NOT NULL ,  
5 last_name VARCHAR(40) NOT NULL ,  
6 email VARCHAR(60) NOT NULL ,  
7 pass CHAR(40) NOT NULL ,  
8 reg_date DATETIME NOT NULL ,  
9  
10 PRIMARY KEY (user_pin) ,  
11 UNIQUE (email)) ;
```

6.3.2 Displaying Plant Information

The plants page displays a selection of the attributes from the plants table. Many more exist in the table to facilitate further development of the application. Displaying the information was achieved through a PHP query to database. The image which follows shows the code and the resulting output on the application.

Figure 22 – Displaying Plant Information

```
<?php
function show_records($dbc) {
    $q = 'SELECT * FROM plants' ;
    $r = mysqli_query( $dbc , $q ) ;

    if( $r ) {
        echo '<table style="text-align: left"><tr><th style="background-color: #99ffbb">Plant Name</th><th style="background-color: #99ffbb">Type</th>
            <th style="background-color: #99ffbb">Soil Type</th><th style="background-color: #99ffbb">Companion Plants</th>
            <th style="background-color: #99ffbb">Pests</th><th style="background-color: #99ffbb">Top Tip</th>' ;

        while ( $row = mysqli_fetch_array( $r , MYSQLI_ASSOC ) ) {
            echo '<tr><td>' . $row['plant_name'] . '</td><td>' . $row['plant_type'] . '</td><td>' . $row['soil_type'] . '</td><td>'
                . $row['companion_plants'] . '</td><td>' . $row['pests'] . '</td><td>' . $row['top_tip'] . '</td></tr>' ;
        }

        echo '</table>' ;
    } else {
        echo '<p>' .mysqli_error($dbc). '</p>' ;
    }
}

show_records($dbc);
mysqli_close($dbc);

include ('includes/footer.html') ;
?>
```

GYO PRO



[Plant Catalogue](#) [Garden Plans](#) [Tips & Advice](#) [Help](#)

Plant Catalogue

Plant Name	Type	Soil Type	Companion Plants	Pests	Top Tip
Broad Beans	Vegetable	Medium	Summer Savory	Aphids, Weevils	Pick pods regularly as this promotes fresh growth.
Beetroot	Vegetable	Medium	Onions	Slugs	Best variety is Boltardy, can be sown in April and will not bolt.
Kale	Vegetable	Medium	Beets	Slugs	Kale survives better in cold weather than other cabbages, and frost will sweeten the flavour.
Courgette	Vegetable	Medium	Beans	Slugs	To aid pollination, break off the male flower and place it on the female flower.
Parsley	Herb	Medium	Asparagus	Carrot root fly	Buy in potted plants and divide up before planting.
Mint	Herb	Medium	Cabbage	Slugs	A very vigorous plant. Can be grown in shaded areas or in containers to stop it invading the garden.
Rosemary	Herb	Medium	Beans	None	Best grown by propagating from cuttings from existing plants.
Strawberries	Fruit	Medium	Onions	Birds	Cambridge Favourite makes a good main-crop variety for Irish wetaher.
Blackcurrants	Fruit	Medium	Marigolds	Birds	Blackcurrants produce most fruit on young wood so prune old wood well.
Gooseberries	Fruit	Medium	Fuchsias	Aphids	Grow bushes with a single leg rather than many stems as they are easier to shape and manage.

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6.3.3 Inserting Garden Details

When selecting the My Garden Details option from the Navigation Bar, the user is taken to a page where they can input the details of their specific plot of land via a form. The form allows them to

enter a name, the width and length, soil details and the sun distribution. The form will reject the pin if it does not recognise it as the registered user's pin, as this links the garden with the user. It is also set to allow numbers up to 2 decimal points in the measurements, and with only accept a soil ph. within a certain range.

This is useful to the user in encouraging them to think about the makeup of the plot, and how areas of shadow will impact on where they can plant. The process was achieved through an insert command, as illustrated below.

Figure 23 – Insert Command

```
// Insert data
$sql = "INSERT INTO garden_plans ( user_pin, garden_name, g_length, g_width,
soil_ph, soil_type, A1, A2, A3, B1, B2, B3, C1, C2, C3 ) VALUES (
'{$mysqli->real_escape_string($_POST['user_pin'])}', '{$mysqli->real_escape_string($_POST['garden name'])}',
'{$mysqli->real_escape_string($_POST['g_length'])}', '{$mysqli->real_escape_string($_POST['g_width'])}',
'{$mysqli->real_escape_string($_POST['soil_ph'])}', '{$mysqli->real_escape_string($_POST['soil_type'])}',
'{$mysqli->real_escape_string($_POST['A1'])}', '{$mysqli->real_escape_string($_POST['A2'])}',
'{$mysqli->real_escape_string($_POST['A3'])}', '{$mysqli->real_escape_string($_POST['B1'])}',
'{$mysqli->real_escape_string($_POST['B2'])}', '{$mysqli->real_escape_string($_POST['B3'])}',
'{$mysqli->real_escape_string($_POST['C1'])}', '{$mysqli->real_escape_string($_POST['C2'])}',
'{$mysqli->real_escape_string($_POST['C3'])}' )" ;

$insert = $mysqli->query($sql);

// Print response from MySQL
if ( $insert ) {
    echo '<h1 style="text-align: center;">Success! Your details have now been saved!</h1>';
} else {
    die("Error: {$mysqli->errno} : {$mysqli->error}");
}
```

6.3.4 Implementation of HTML & CSS

HTML was the core building block of the site. Each page shared a header.html, navbar.html and footer.html. This avoided unnecessarily repeating code that would be used by each .php file. A styles.css document provided consistent structure and appearance, again avoiding the need to unnecessarily repeat code.

Cascading Style Sheets were developed to facilitate separation of the content and style of a site. Confining the styles for all pages also means that any changes to style only need to be made in one location to take effect in all locations.

Colours and font in the style of those selected by the Focus Group were used across the site via the css file.

6.3.5 Drag & Drop Function

The drag and drop function is a key feature of the application. It allows the user to move the plants around the plot, to get a sense of where they could be located in their own patch of land. The plot can be refreshed at any point if the user wants to change the planting plan.

The idea of expanding this function to allow the saving of plans was extensively explored but was not fully operational before submission. The code has been attached as Appendix 6 for reference and the idea is included in the further development section of this report. Screenshots of the code are included below.

Figure 24 – jQuery Drag & Drop Code

```
<script>
src="https://code.jquery.com/jquery-3.1.0.min.js"
integrity="sha256-cCueBR6CsyA4/9szpPfrX3s49M9vUU5BgtiJj06wt/s="
crossorigin="anonymous"

var numDrops = 0;
function allowDrop(ev) {
    ev.preventDefault();
}

function drag(ev) {
    ev.dataTransfer.setData("text", ev.target.id);
}

function drop(ev, region) {
    // location is the value of the cell
    // Get the image that has been dropped
    var data = ev.dataTransfer.getData("text"),
        myImg = document.getElementById(data);

    // Add image to correct box
    ev.target.appendChild(myImg);
    ev.preventDefault();
    console.log("image src = ", myImg.getAttribute("src"));
}
</script>
```

```
<tr>
  <td style="width: 20px">2</td>
  <td id="A2" ondrop="drop(event, 'A2')" ondragover="allowDrop(event)"></td>
  <td id="B2" ondrop="drop(event, 'B2')" ondragover="allowDrop(event)"></td>
  <td id="C2" ondrop="drop(event, 'C2')" ondragover="allowDrop(event)"></td>
</tr>
```

```


```

6.4 SUMMARY

This chapter has detailed the implementation platform selected, and how some of the key functionality was achieved. Specific algorithms have been presented and explained. Challenges arose in the actual implementation which took time to resolve. These challenges and the solutions employed, have also been described.

Despite the level of detail in the design stage of the project, the implementation stage was more time consuming than anticipated. However, the application was successfully implemented and key functionality was achieved.

7 TESTING AND EVALUATION

7.1 INTRODUCTION

This chapter outlines the testing and evaluation of the application. Each category of testing is outlined, and a table summarises the results is included for ease of reference. The chapter ends with a summary of findings.

7.2 TESTING

Testing loosely followed an agile development approach. The developer tested after each completed phase, with the goal of a web based application fully useable and functional on a range of browsers.

Testing was categorised into three main areas and was carried out on an Asus Notebook.

- In house functional testing
- Cross browser testing
- Test Group testing

Asus Notebook PC SKU

Intel Core i5 - 5200U

2.2 GHz

8Gb RAM

64-bit Windows 10 OS

15.6inch display screen

7.2.1 In House Functional Testing

In house testing was carried out by the developer on an ongoing basis to ensure all intended functionality had been achieved. Each aspect of functionality was examined as it was developed.

7.2.2 Cross Browser Testing

Cross browser testing was considered a necessity as there are a number of internet browsers currently available and the application could conceivably be accessed by any one of them. The browsers tested were Google Chrome, Internet Explorer and Mozilla Firefox.

The functionality across each browser was considered. Continuity of presentation was also tested. The results of this testing has been tabulated and presented in Table 8, below.

Table 8 – Cross Browser Table

Functionality	Google Chrome	Internet Explorer	Mozilla Firefox
Page displaying as expected	✓	✓	✓
Navigation & links functioning	✓	✓	✓
Connection to database operational	✓	✓	✓
Drag & drop feature functioning	✓	✓	✓

7.2.3 Test Group

In order to test how usable and intuitive the application is for the end user, a Test Group was established, membership of which was drawn from the Focus Group. Testers were given a brief explanation of the application and given an opportunity to familiarise themselves with it.

Test Group Members were then asked to complete 3 specific tasks to determine the ease of use and navigation of the application. The subjects were asked to rate the ease with which they were able to perform each task on a scale of 1 to 5, with 1 being very difficult and 5 being very easy. This exercise was observed by the developer in case testers needed assistance, and to gather qualitative information, such as whether tasks were performed with relative timeliness. There

were no significant deliveries and all tasks were performed in a timely manner. Table 9 presents the results.

Table 9 – Results from Test Task Exercise

Task No.	Description of Task	Task Completed
1	Please register as a user and login.	Pass
2	Navigate to the Garden Details section, and input the details of a patch of land.	Pass
3	Add 3 plants to the Planting Plan.	Pass

Testers were also asked to rate key aspects of the application through their response to 5 statements. Testers rated their agreement with the statements on a scale of 1 to 5, with 1 representing Total Disagreement, and 5 being Total Agreement. A summary of the results for each statement is presented in Table 10.

Table 10 – Summary of Results from Test Group Questionnaire

Statement Presented to Test Group Members	Average Mark (5)
Overall, the layout is clear and easy to follow.	4
The drop down menus are easy to use.	4.5
The colours used are appropriate and attractive.	3.5
The font selection is appropriate and easy to read.	4
Overall, the site is easy to navigate, I can find what I am looking for.	4

Average overall score based on results from all 7 questions is 4 out of 5.

7.3 SUMMARY

This testing for this application was extensive and thorough, being performed across 3 categories. Results were presented in tabulated form for ease of reference.

In house testing verified that functionalities were performing as expected. Cross browser testing proved that implementation was fully successful. Testing with the Test Group members has confirmed that accessibility and usability has also been achieved.

Overall, this would suggest a successful, although not flawless implementation of the brief. Feedback and recommendations by the group was received with thanks by the developer and all suggestions have been incorporated into this report.

8 CONCLUSIONS

8.1 INTRODUCTION

Chapter 8 is a summary of the project work from inception to completion. The success of the project plan, adherence to timelines and any lessons learned will be discussed and presented. It will outline the conclusions arrived at by the developer, and closes by outlining suggested avenues of further development of the application.

8.2 PROJECT SUMMARY

The early stages of the project were devoted to a comprehensive study of gardening and 'growing your own'. The increasing interest in gardening is considered in the context of a global recession and an increasing interest in self-sufficiency. This is presented for the reader, and gives a context to the rising number of gardening applications available. A succinct problem statement was crafted to aid the developer.

Five applications on the market were reviewed as possible solutions to the problem. Their pros and cons were considered and evaluated. The results of this exercise were used to draft the Focus Group Questionnaire, which was distributed to the Focus Group.

Feedback from the Focus Group was instrumental. This feedback, combined with the information from the research and analysis stages, guided the developer in identifying the functional and non-functional requirements of the application.

Additional research was carried out to support the process of designing the application. Resources such as Code School and the W3 Initiative were utilised to ensure the correct principles were followed using the correct skills. This ensured a clear structure could be designed with a consistent feel.

When designing the User Interface, development focused on the needs of the end user, many of whom could have poor IT literacy.

Storyboards were produced, including pseudocode, to ensure that every facet of the site had been envisioned. These formed a road map for coding. A site map and home screen mock ups were also produced as visual aids to the process.

An Entity Relational Diagram clarifies the database structure supporting the site.

The client server relationship was defined and a combination of languages were ear-marked for use. On the client side HTML5, CSS and jQuery were identified, with PHP and MySQL being adopted on the server side. The languages worked together to ensure data was responsive when loaded on the client side, and server side requests were responded accurately.

The level of detail in the design stage was helpful when beginning the implementation. The storyboards were also useful for the implementation and testing stages. Despite this, coding in new languages took up more time than anticipated. Each phase of coding was tested, allowing issues to be immediately identified and particularly challenging aspects of the coding, such as the AJAX function, to have more time devoted to them.

Testing ensured the production of a successful project. Three key areas of testing were identified. External testing was carried out by the Test Group under the observation of the developer. A Test Task Exercise with additional questions was distributed to members and they were asked to work through the tasks and rate the application at the end.

8.3 EVALUATION OF PROJECT

The project began with a clear and concise aim and six objectives. In evaluating the success of the project, one must assess if they have been achieved.

1. A review of applications on the market and an evaluation of their key features was carried out in the early stages of the project. This aspect was crucial in assessing if the solution to the problem already existed, what elements of other applications were advisable to replicate, was features were relatively unimportant. It was also useful in achieving Objective 2.

2. A short questionnaire was developed and administered to a Focus Group of key stakeholders. Before the initial Analysis Report was submitted, ten people were recruited to a Focus Group. The developer was fortunate to meet with members in the early planning stages. The group ranged in age, gender, social background and gardening skill. Using the information gleaned from the systems analysis, a short questionnaire of nine questions was drawn up and distributed to the group.
3. Findings were reviewed to develop a list of functional and non-functional requirements.
4. A visually appealing user interface was designed that is easy to navigate and contains relevant information. The interface is clearly laid out, making use of an appropriate colour scheme, font and imagery.
5. A prototype was then created to ensure strong functionality and design in the finished product. Several drafts of the storyboards were produced to ensure every facet of the site had been envisioned and the necessary algorithms considered. This was essential before any coding could be attempted.
6. The system was fully tested and evaluated. Testing was in three categories. Results from the testing process were positive, indicating the application was successfully implemented.

As the objectives and aim have clearly been achieved, it can be asserted that the project was successful. A number of suggestions for further developments were made by the Focus Group and the developer, which have been included as recommendations.

8.4 RECOMMENDATIONS

There are a number of recommendations that would be included should additional time and resources have been available.

- The free-hand sketch element was extensively researched, and some early prototypes using HTML5 technology were developed. These proved not to have the required

sophistication for the application, however. More sophisticated solutions were explored, but had much greater memory requirements. A key recommendation for further development would be to have this feature included in an elegant way.

- Greater emphasis on the appearance of the garden over time would be useful, as this is something many beginner gardeners often overlook. This feature would illustrate the full grown size of any trees or shrubs planted, as the current application only considers plants grown for food. The beginnings of this aspect are in the application, as the plants table does contain the dimensions that plants will grow to, however this information is not part of the planting plan page so users do not benefit from it.
- Planting Plans should be saveable and deletable. Currently the planting Plan function is useful to assist gardeners get a sense of their space, but further development would see this as a process that can be saved.
- The plan could warn users when they attempt to plant in an inappropriate location. For example if the plant they select requires full sun but the area of the garden where it is dropped is full shade.
- A personalised calendar was agreed by Focus Group members to be a useful addition. Further development would see this integrated into the project, with events such as harvesting being automatically inserted into the calendar when plants are included in a plan.
- A more in-depth section on common pests could be included, with tips on how to best deter them.
- The section on storing and preserving produce could be extended to include a range of recipes.
- Links to distributors of heritage seeds, 'grow your own' equipment, books, local classes and other relevant items could be included.
- A function to bookmark relevant sites and further reading on the subject could be included, benefiting the user by having relevant information all stored in one location.

8.5 SUMMARY

This project began with the clear aim of developing a region-specific application, to assist the enthusiastic amateur gardener in their modification of a small urban growing space.

A suitable application was designed and developed based on the developers own research, engagement with the Focus Group and the results from the Focus Group Questionnaire. The web application was successfully implemented, ahead of the timeframe, and underwent thorough testing, by the developer and the Test Group.

All objectives supporting this aim have been delivered and the aim realised. An application, surpassing the expectations of the developer has been produced, utilising previously unknown technology, fulfilling all functional and non-functional requirements. It will be a valuable resource to the beginner urban vegetable gardener.

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10 APPENDICES

Appendix 1 – Rich Picture

Appendix 2 – Focus Group Questionnaire Sample

Appendix 3 – Storyboards

Appendix 4 – Sitemap

Appendix 5 – Test Group Exercise Sample

Appendix 6 – Code