Live from the Hive: a design proposal for a physical system for the Lions' Gate permacultural gardens

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Design Dialogues Coursework 2

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1. Introduction

The system which has been developed for this report – Live from the Hive - is best described as a digital beehive, designed to provide a real-time visual and educational insight into bee lifecycles. Motivated by the requirement that the system demonstrates how permaculture and user experience can be blended, as illustrated by Egan et al. (2017), the system incorporates both biological and technological components within the physical and digital spaces.

At a biological level, there are three components required to establish and promote bee lifecycles within the physical space;

- a traditional beehive for honey bees,
- a bee hotel for more solitary bee species and
- a flower bed seeded with wild flowers, in which the plants will be chosen specifically to attract bee activity.

The technological components have been selected with the primary intent of supporting a live visual feed of bee activities, while minimising the need to draw on non-sustainable materials or to intrude unnecessarily into the bees' physical space and disrupt their activities:

- cameras with night-vision and audio capabilities, seeded in the biological components to provide live transmission
- a wireless router to handle communications from the cameras
- tablet computers made available on-site for interaction with the camera system, while providing educational materials for users
- a server for storage and maintenance of the web-based application the tablets will require, and from which remote users can access the service
- solar panel and wind turbine systems to power the technological components and minimise reliance on grid electricity.

This project is inspired by the central importance of the bee lifecycle in the pollination of plants and flowers (James and Pitts-Singer, 2008, p.8). By extension, the desire to

educate people about this importance is balanced by an understanding that involving people in a subject by showing them can often be more inspiring to action than simple description. The level of involvement can be extended from a simple educational resource to providing student volunteers with a grounding in permaculture and blended spaces through the assembly and maintenance of the digital beehive system. While the system is intended primarily as an educational resource, however, it can be argued that it may be valuable to researchers conducting studies with bees by providing a resource for research into the bee lifecycle within an urban permacultural environment. A further objective is for the system to be as sustainable as possible on a biological, technological and to a lesser extent on a financial level. This could arguably be achieved by careful maintenance of the bees' environment, through the use of donated rather than new equipment and through sensitive harvesting and sale of the honey and beeswax generated within the honey bee hive.

2. Design approach

The design approach being used for this report, out of necessity, considers the construction of the Live from the Hive system primarily on a conceptual basis. Creation of a physical prototype of a system would be almost impossible due to the specific requirements of the biological components detailed in the introduction. The design approach being used here is intended to be sufficiently descriptive of the envisioned system that, with the available resources, it would be at least possible to begin the design of a physical prototype. On his basis a scenario-based approach, as specified in Benyon (2017) is being used due to the author's existing familiarity with it. Here, the emphasis is on the development of personas and user stories through which the potential user base can be determined. Using these, scenarios can be developed in which users might seek to use the system. These scenarios will provide situations for testing and evaluation of the system, and will help determine how the proposed conceptual system could subsequently evolve into a fully realised and functioning system in a blended space.

3. Understanding

3.1 Brainstorming session

The current project grew out of a brainstorming session carried out at a Design Dialogues workshop, which generated ideas for a number of different systems which could be incorporated into the Lions' Gate garden. As can be seen at Figure 1, one of the suggestions was the idea of a digital bug hotel or beehive. During discussions on the viability of the potential projects which might stem from this session, the author was persuaded by the arguments for the digital beehive project to such an extent that he decided to investigate this rather than his own suggestion of projection units on the fire escape above the garden site.

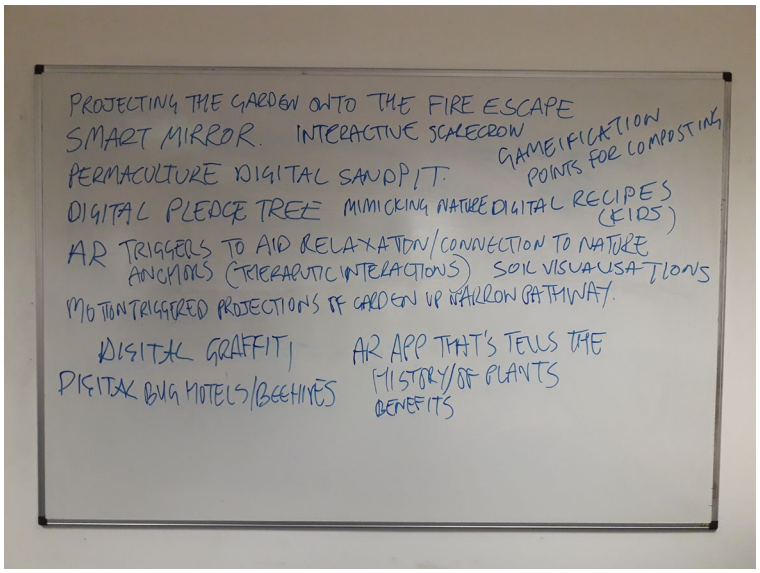

Figure 1 Brainstorming session board

3.2 Online research

3.2.1 Research into bee environments

As mentioned in the introduction, bees are central to the function of the pollination system for plants and flowers (James and Pitts-Singer, 2008, p.8). However, they are also vulnerable to the effects of human activities, such as chemical contamination (Slater, 2015). One of the unintended consequences of such activity, it is argued, is the decline of bee populations across the world; this perceived decline has prompted an interest in bees' well-being and led to an

increase in the use of urban hive systems (MacIvor, 2016). Such systems are arguably what come to mind when people consider what a beehive is. However, the primary concentration on honey bees in such environments may draw attention away from the needs of wild bee populations and affect species diversity (Ollerton et al., 2012). Arguments such as Ollerton et al. therefore prompt thinking about facilitating environments for species other than honey bees, so that the permacultural environment helps maintain biodiversity. An example of this can be seen in the use of bee hotels (see Figure 1) to attract solitary breeds, with greater success recorded where these face toward the sun (Gaston et al., 2005) although further research into the benefits of bee hotels is required (MacIvor and Packer, 2015). For the purposes of creating a digital beehive for an educational experience, it may be argued that the presence of both types of habitat provides greater scope for achieving this aim. To help illustrate the pollination lifecycle and simply to feed and water the bees, the flower bed within the permacultural space will need to contain flowers and plants attractive to bees as well as a repository for rainwater collection. The Goulson laboratory at the University of Sussex (2018) recommends a number of bee-attractive plants for seeding a flower bed, although further research will help to determine which are best suited to an urban environment 600 kilometres north of the Goulson site.

Figure 2 Example of a bee hotel structure

The construction of the bee habitats could be handled in a number of different ways. There are a number of vendors who supply pre-manufactured bee hotels, which could initially serve the purpose if time to develop the habitat was short. It may be argued, however, that a permacultural space such as the Lions' Gate would be better served in the long term by the use of a sustainable solution such as that proposed by Friends of the Earth (2018). Such a solution would benefit

enormously from the unique contributions of design students within both the university's school of computing and the school of arts and creative industries. The construction and siting of a traditional hive for honey bees would arguably benefit, however, from the input of a beekeeper or a researcher specialising in the study of bees.

3.2.2 Research into technological environment

Having developed an understanding of the bees' environment, it became necessary to understand how that environment could be blended with available technology and how that might be made sustainable. Firstly, given the speed of technological advancement in touch-screen devices, the argument can be made that many such devices are discarded by their owners before the end of their useful life. These devices could be collected from donors and re-tasked for the specific use of the Live from the Hive system, replacing them with fresh donations as they cease to function. Similarly, the video feeds for the bee hotel and the flower bed could be driven from out of date but still functioning mobile phones. A system element such as this would operate on a similar basis to that proposed by Jansen (2018) for a home security camera, although consideration must be given to the best ways to protect such devices from a local climate which can be unpredictable even in summer.

Figure 3 Obsolete mobile devices for capturing video feeds

Such cameras would be less suitable for installation within the traditional honey bee hive as their size would make them intrusive, and therefore disruptive to the bees' lifecycle. Minimising such disruption would be extremely important, especially if the hive is to be a beneficial resource for the research community. Installation of cameras inside a traditional honey bee hive is certainly viable from

a technical perspective; an example of a live video feed from a hive in Bavaria can be seen in the explore.org website (2018). A potential solution can again be found within home security; examples of night-vision cameras with lens diameters of under 4mm can be obtained for threading into the hive, with the power and wireless pack attached to the outside. An example of the logistics of seeding beehives with cameras is described by Griffin (2014), although it should be noted that the cameras used here are re-tasked from use within bird feeders.

Perhaps the most pressing concern in relation to introducing this form of interactive experience is establishing how it can be powered. Given that the project design brief explicitly specifies that the system should consider renewable power sources, a desirable solution would be the avoidance of the use of grid electricity wherever possible. The geographical and physical location of the Lions' Gate gardens – beneath an eight-storey building, itself sited 100m above sea level – lends itself very well to the use of a wind turbine mounted on the roof of the building. In addition, solar panelling would be beneficial in maintaining an electrical supply for the system, especially in summer when the Edinburgh area can see up to seventeen hours of daylight in the second half of June.

3.3 PACT Analysis

Establishing how the system might work in practice, it can be argued, is only as beneficial as establishing who might get some use out of it and why the system might appeal to them. To this end, the Design Dialogues class carried out a PACT analysis of the digital beehive idea; the table this generated can be seen at Figure 3. From this basis, user personas and scenarios could be generated in order to test and evaluate elements of the system.

People	Activities	Contexts	Technologies
Beekeepers Schoolchildren Bees Garden maintainers Canteen workers Programmers / IT Students (Bio students) Outside visitors Stream viewers Researchers	Looking at bees doing stuff Learn what they're up to Get rewarded with honey? Set tasks: Bring back plants Find a missing drone Do the waggle dance Be the queen Stream viewers: Interaction? Change the lights Choose a task Make a buzz sound	Time of day – do bees sleep? Temperature – bees don't do much in the cold Separation: Getting stung Visitors killing bees Symbiosis – flowering plants / pollination Marginality: Using old plant pots? Topology of the hive Animals that eat bees	Cameras (IR / night vision) NFC tags / readers Router Solar panels Local tablets The hive itself Web server Website Bee hotel Sensors Actuators

Figure 4 PACT analysis table

4 Envisionment

Having developed an understanding of the system requirements and, more importantly, of the types of users who might benefit from interaction with the system, we can now begin to consider what the system might look like and the specific environment in which it will be installed. Here, three envisionment methods have been selected, each with the specific intent of showing people what might be difficult to describe using words alone. A storyboard helps to show a simple pathway through interacting with the system, a map of the elements of the physical system helps to illustrate what would be needed to make the projected system function, and an interactive wireframe describes the user interface and what an early iteration of the system could be expected to do.

4.1 Storyboard

The storyboard at Figure 4, generated during an envisionment workshop for the Design Dialogues module, considers a very basic storyline for what a digital beehive might look like and how it might function within a permacultural environment. It discusses seeding a traditional beehive with cameras, and tethering these and a router and tablet computer to a power system run from solar panels. Further, it covers the possibility of gamifying the educational aspects of the system. At this stage, it should be noted that the priority for the system is setting up the core video and educational functionality with a view to expanding into gamification functions once the system is up and running. Similarly, the storyboard does not address wind power as a source of electricity; however, as discussed in section 3.2.2, the location of the gardens would present an excellent opportunity for using this form of renewable power.

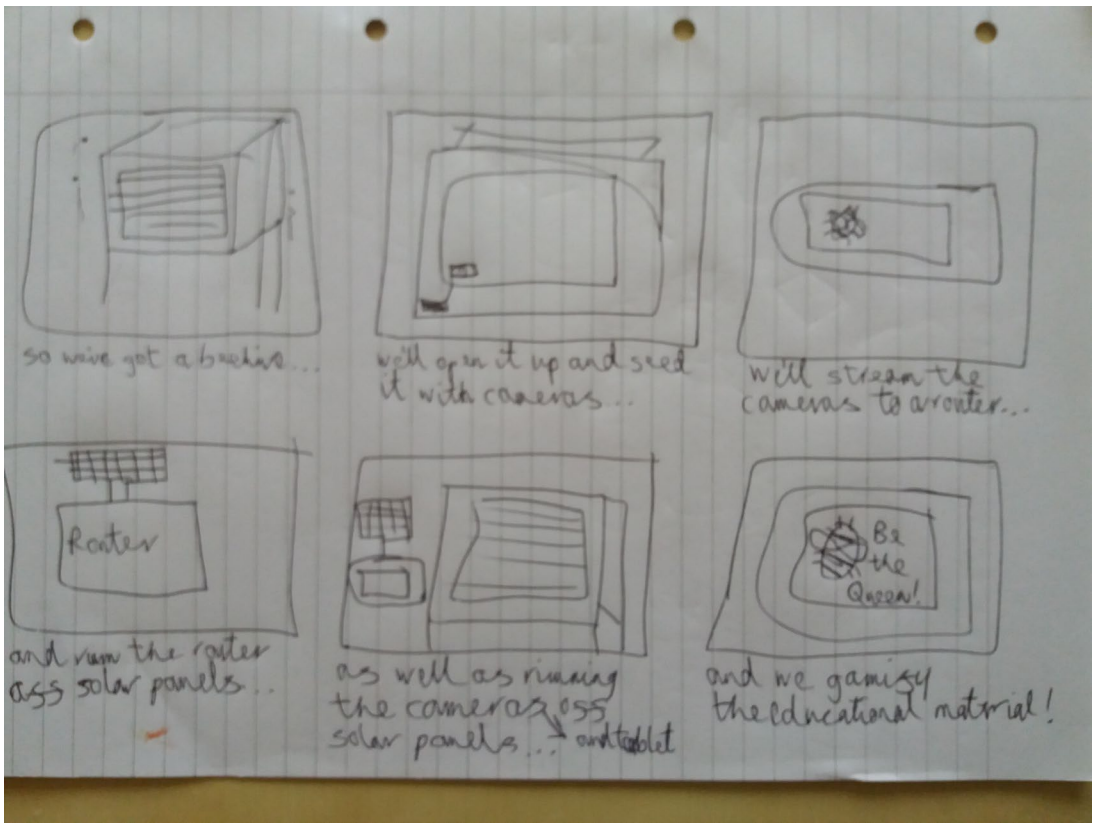

Figure 5 Storyboard sketch from Envisionment workshop

4.2 Physical system map

Figure 5 illustrates the physical aspects of the system as described in the introduction. Technological components are shown with a white background while biological components are shown in blue. To simplify the map, the system is described with only the solar power system; for the wind-powered aspects of the system, the solar panel and solar-charged battery would be replaced with a wind turbine and turbine-charged battery.

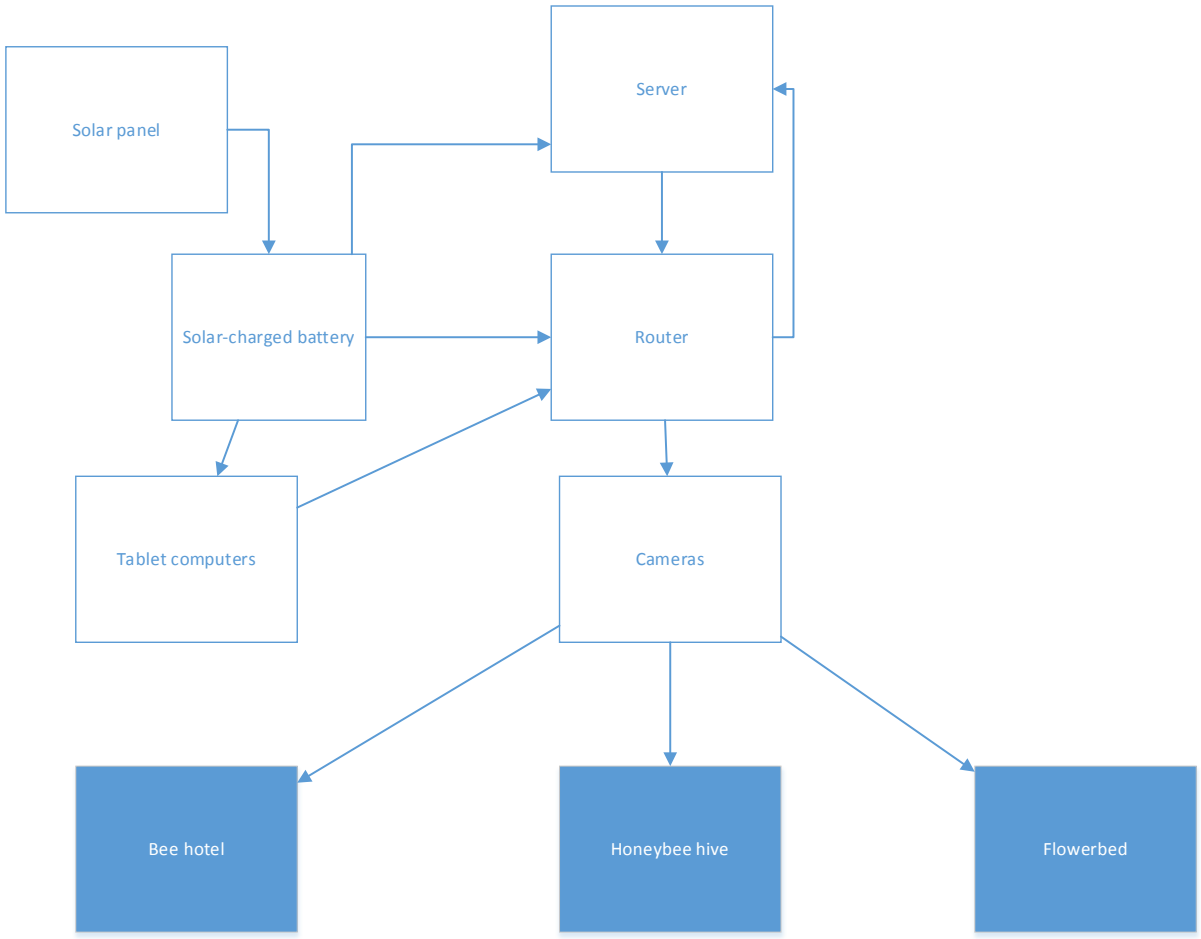

Figure 6 Map of the physical systems

4.3 Interactive wireframe

To help illustrate the tablet-based interactive section of the system, and to facilitate testing, a simple interactive wireframe of the main screens was developed through Moqups (available at https://app.moqups.com/marcfairbairn/A2DdnkT32E/edit/page/aa9df7b72) as illustrated at Figure 6. This highly simplified wireframe connects the pages together, describing the links from one video feed to the next and to the educational and sales pages. The primary stylistic theme here is one associated with bees for many people, namely the hexagonal shape of honeycomb cells coupled with a shade of yellow close to that of honey.

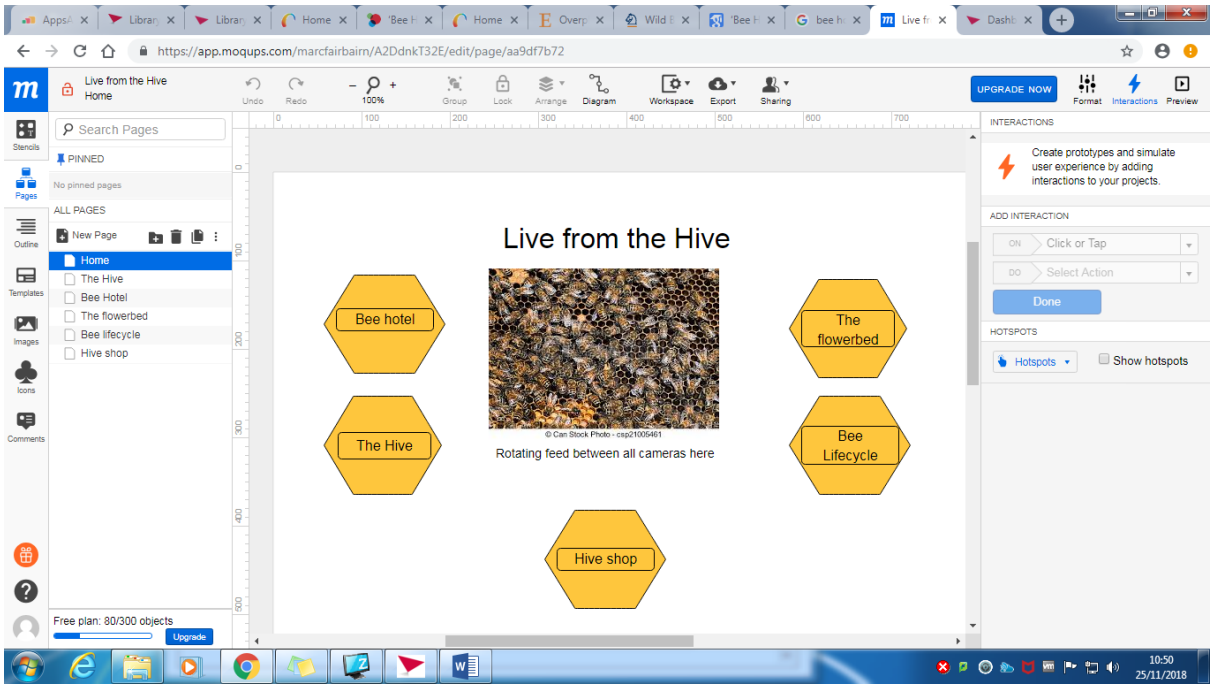

Figure 7 Screenshot of the Moqups front page

5. Testing

5.1 Scenario-based testing

The development of a PACT analysis subsequently provided a series of personas. In order to determine how users might interact with the system and how it might be revised based on such interactions, scenarios using these personas were generated and presented to a volunteer. The volunteer, following the scenarios, then interacted with the interactive wireframe and provided feedback for each scenario.

5.1.1 Persona and scenario 1 – Harry

Harry is 19 years old and an undergraduate student at Edinburgh Napier University. He's long been interested in insects, and wants to be able to look at bees and to be able to show off his knowledge. However, he's not keen on traditional learning methods. He's also interested in volunteering at the Lions' Gate and wants to learn about the available options.

The scenario for Harry is one where he wants to learn about the bees and their behaviour. He accesses the Live from the Hive tablet at the digital bothy and works his way through the available options, moving from camera to camera and then on to the educational resource and sales pages.

"This is a pretty simple piece of software and I knew where to go to look at each camera feed. From what you've said about the Home screen, the feed there switches from one camera to the next automatically. Can we have a way to stop the switching on the front page if something really interesting comes up? Also, I know the bee lifecycle stuff isn't on there yet, but it's not just going to be a load of essays, is it?"

5.1.2 Persona and scenario 2 – Emily

Emily is 23 years old and a postgraduate student in entomology at another university. She's particularly interested in the bee lifecycle and the pollination process as part of her wider research.

The scenario for Emily envisions her using the video feeds to observe and record information about bees in an urban permaculture environment. She accesses the Live from the Hive application from a remote computer and spends some time watching each video feed.

“It’s been useful to see how you’ve gone about monitoring the bees using the camera system. I’m a little bit concerned about the positioning and size of the cameras though. It’s vital that the cameras, and any work you have to do on them, don’t disrupt the normal working of the hive. Thinking about it, you’ll need to make sure that the material on the bee lifecycle isn’t too academic when it goes up, or it won’t hold people’s attention.”

5.1.3 Persona and test scenario 3 – Suzanne

Suzanne is 42 years old and a chef in one of the university restaurants. As well as enjoying cooking both at work and at home, she’s interested in gardening and nature. Suzanne’s interested in the systems in the Lions’ Gate that generate some of the restaurant’s produce and is keen to learn about this new section.

The scenario for Suzanne is one where she’s using Live from the Hive to learn all about the hive, as she has little previous knowledge. Suzanne accesses the application from a tablet in the digital bothy and takes a tour of everything the app currently offers.

“It’s interesting to see close up where the honey’s going to come from, and I didn’t think a lot about there being different types of bee. There’s a couple of things I’d like to see, though. If you’re going to be selling some of the honey, maybe people would be interested in recipes using honey and they could be put up? Oh, and my wee boy loves stuff to do with bugs. Are there going to be bits on here for kids to play with?”

5.2 Usability testing – user interface

To avoid disruption to the often sensitive lifecycles of the system’s inhabitants, the user interface will be the users’ primary means of interaction with the system. To this end, it is important that the interface is tested for usability. The initial design was assembled on Moqups, and the controls were then tethered to

specific pages to simulate moving through the application. This test established a number of potential issues with the user interface as generated through this wireframing system, not least of which was a limited capacity for implementing the backdrop intended for the system. As a result, the test module presented for scenario-based testing is plain white rather than the golden honeycomb colour intended. A further constraint was being unable to present a video feed, given that the core function of most of the screens is video-based. As a substitute, still images were placed on the wireframe as a guide. Finally, insufficient care was taken by the author in connecting the screens together, resulting in some of the click buttons failing to work during testing and, later, during evaluation.

6. Evaluation

6.1 Co-operative evaluation / Discount Usability engineering

One of the methods selected in order to carry out evaluation of this project is co-operative evaluation. This is expedient given that it allows for several evaluators to work together on establishing the benefits and deficits of the system. With this in mind, the storyboard and interactive wireframe generated at the envisionment stage were presented by the author to four of his fellow Design Dialogues students. In order to establish a basis for evaluation, it was collectively decided to use the criteria derived from discount usability engineering to keep the discussion to three core themes; namely, learnability, effectiveness and accommodation. By this method, it was possible to quickly gather qualitative data and to evaluate how this could improve the existing proposal. The group rated the learnability function highly due to the simple and uncluttered nature of the control panels on each page. In addition, the hexagonal and honey-coloured controls came in for praise. It was, however, also pointed out that not all controls on each screen of the wireframe appeared to link to the other pages. This was something which was not detected at the testing stage; this means that the wireframe would benefit from revision, followed by a further round of user testing. In terms of effectiveness, the simplicity of navigation and control was seen as beneficial although the matter of feedback and being able to back out of any given page was also raised. Based on this evaluation criterion and the discussion it prompted, each page of the completed interface will contain a direct link back to the home screen. Turning to accommodation, the style of the control system was praised for its consistency with perceptions of the honeycomb structure of a traditional beehive. However, it was also discussed that the storyboard's reference to gamification did not appear in any of the functions presented in the wireframe. The author explained to the group that his focus at this stage of development is on getting the core functions of the system in place before moving on to gamification, which would be incorporated at a later stage in development. A further suggestion made by the group involved including some of the educational information as an on-screen crawler at the base of the video feed window, similar to that seen on rolling news channels on television and news websites. This recommendation was something that the author had considered briefly, and not in

any depth. This provides a means to open up the educational aspect of the system for casual users who may be less interested in an in-depth investigation of the educational pages on the interface.

6.2 Presentation of 22 November 2018 and subsequent queries

As part of the Design Dialogues workshop series, the author created a presentation in order to describe the Live from the Hive concept at the closing workshop, a copy of which is available at https://moodle.napier.ac.uk/mod/forum/discuss.php?d=177540 and which has also been zipped to this report. This provided a further opportunity to collect qualitative data from the audience for evaluation and to try to answer further questions about how the system might operate. A number of questions arose from the content of the presentation over the following week on varying aspects of the system.

Q. “How would you deal with the hive camera becoming obscured by bees’ by-products?”

A. This was a point which hadn’t been considered prior to the presentation. Further, the presentation does not make clear how many cameras would be mounted within the hive. On further contemplation of this issue, it would be necessary to install more than one camera within the hive. This would maintain a continuous live feed in the event that a camera had to be removed for repair or replacement.

Q. “How would you ensure that the system sustains interest for more than one visit?”

A. The presentation covered the initial phase of development, namely the creation and installation of the system and how the user interface would work. It is envisioned that subsequent phases of development would include previously discussed elements which could encourage repeat visits, such as gamification of aspects of bee behaviours.

Q. “What happens to Live from the Hive once autumn sets in?”

A. The live feed from the hive would still be available throughout the winter. While workers and male drones die off in autumn, the queens can pass the winter in the hive, safe from predators and generating sufficient heat to survive the winter once temperatures drop below 10 degrees Celsius (Clark, 2017). The bee hotel will

probably consist of sealed nests for bee eggs and larvae at this point (Clark, 2017), so activity from this camera is likely to be minimal. The camera focusing on the flower bed might be re-tasked to observe the activities of other insects and birds during the winter period. This is in itself an educational opportunity for users, as it helps to address questions about the bee lifecycle during a time where bees' presence is not immediately noticeable. From a technical perspective, this may also be the point at which most of the major maintenance could take place.

Q. "A system with cameras inside the hive could potentially be upsetting to a bee colony. How would you approach this?"

A. It would be absolutely necessary to involve a beekeeper or a researcher in the physical design and development of the system, to ensure that the non-human users of the system are looked after as well as the human ones.

7. Conclusion

The current project has sought to illustrate how a physical system for observing bees could potentially be integrated into the Lions' Gate permacultural garden. The physical scale of the technological system components have meant that the use of a physical prototype would have been extremely difficult. In addition, there are profound ethical considerations which would need to be evaluated before any attempt could be made to construct a blended system which includes living beings, whether these are the users or the hive's inhabitants. The methods used here expand significantly on the scenario-based design method in that testing and evaluation have been incorporated into the design thinking. This is not to say, however, that the scenario-based method lacks value; it has been used in order to consider which kinds of users might interact with Live from the Hive and what their motivations might be. The testing regimes used here are justified in that respect as the personas and scenarios are those of people who might reasonably be expected to interact with the system on a regular basis. However, these would have benefited from additional numbers of testers and the perspectives they would have brought to the tests. The evaluative methods used have proven extremely valuable in the gathering of qualitative data about improvements to the system and further potential scenarios, since no UX designer can ever expect to grasp all the potential pitfalls or scenarios a design might present. However, there may have been benefits in carrying out further evaluation on a quantitative basis, using heuristic evaluation and grading the elements using a Likert scale. Without referring a design to other people to look over, to play with and to try to break, a designer will almost certainly submit a design which fails to meet the client's requirements.

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(Conclusion word count: 299)

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