

C. Design the Testing

The focus of the testing is to evaluate usability criteria with regard to modality, focus/context, and ease of direct manipulation on a small-screen interface. Three methods of testing will be used:

1. Heuristics Evaluation
2. Cognitive Walkthrough
3. Think Aloud

As previously described, PlantTracker® has *navigation mode* (tapping on the screen provides semantic zoom; dragging provides pan) and *reading mode* (tapping on the screen provides detailed content on a specific item selected; dragging provides a list of items selected).

Since the tapping gesture in reading mode yields location information on missed targets, the gesture can be appropriated by the user for navigational use. This can potentially allow for slips whereby the context of the user's skilled behavior has been changed, and the user has forgotten or is otherwise unaware of this change.³¹ Therefore, feedback on modality becomes critical.

Testing Method 1 – Heuristics Evaluation (See Addendum D)

Since the likelihood of slips has already been established by potentially “misappropriated” gestures³², heuristics evaluation is useful because it can ascertain the quality (or severity) of the potential problem.

According to Nielsen, evaluation by five to seven different HCI experts uncovers approximately 75% of usability issues. Three experts will be asked to evaluate completed portions of the interface, without intervention. Since PlantTracker® is domain-specific, evaluators may be supported during their exploration, only by answering questions on domain-specific terminology or actions. The experts will then provide a written evaluation by listing problems, and rating them in three ways. First, problems will be evaluated for frequency, from 0 (least frequent) to 4 (most frequent). Second, evaluation will be for impact, with 0 being least severe to 4 being most severe. Third, they will be evaluated for persistency (0 for least persistent to 4 for most persistent). The following six areas will be evaluated:

1. Visibility — Persistent and appropriate feedback in reasonable time is best evaluated through a fully functioning prototype. Quality of evaluation of this criterion may be limited by an immature prototype.

³¹Dix, Alan, Janet Finlay, Gregory Abowd, Russell Beale. *Human-Computer Interaction*, 2nd Edition. Harlow, England: Prentice Hall Europe, 1998, pg. 46.

³²In designing user-centric tools, it is incorrect to assume that any unintended use of the tool is a misappropriation of that tool. Rather, the designer must anticipate and leverage user behavior — both intuitive and learned — to turn a potential liability into an asset.

2. Match Between System and the Real World — PlantTracker® should present information that a user would expect to find in a botanical garden. It should be presented in layman's terms to accommodate the novice. It should be accessible through a logical sequence of actions. The physical space should be matched both in scale and with visual cues on any level of magnification in all views. The user's direction of movement and orientation should be matched. The user's mental model of actions should also be matched to the different modes: navigational mode matched to the real space, and reading mode matched to a hierarchical organization within the fields of botany and landscaping.
3. User Control and Freedom — PlantTracker® should allow for easy recoverability. A home button is an easily recognizable convention for immediate recovery to the session's original state. It is, however, unconventionally incorporated into the overview. A persistent overview is offered to assist with incremental recovery. This is in anticipation of when users may accidentally change the level of magnification on the map (while believing to be in reading mode) and wish to return to a previous view. The user who is comfortable with navigation in the interface experiences freedom to explore unknown areas knowing they can return to known areas easily.
4. Consistency and Standards — Since the buttons for filtering various attributes are of different types, and require different actions by the user, the level of consistency should be evaluated. Most of the buttons are dual sliders (like "height" and "width"), and should operate with a consistent click-and-drag action along a specified path. Others (like "flower color") are free-form selection tools. Still others (like "zone map") are area-click tools. Different cursor shapes that reinforce the type of action to be used might confuse the user. Also, the navigation mode gestures should be consistent with popular conventions (tap to zoom, drag to pan, scrollbars to pan), and reading mode gestures should be consistently implemented (closing windows, selecting text, etc.).
5. Error Prevention — Anticipating all possible uses and user methods by a widely diverse group of users is the primary challenge for error prevention. Allowing HCI experts to thoroughly explore a well-developed prototype provides the best opportunity for a complete evaluation. Therefore, the limited development of this prototype is a liability in evaluating error prevention.
6. Recognition rather than Recall — A system that stands to be used infrequently or by a widely diverse user group should have a clear and concise interface. Users should be able to recognize objects, options and available actions instead of trying to recall them from a past visit, or with limited technological experience. Users should also be able to recognize which mode they're in prior to tapping, instead of trying to remember.

Testing Method 2 – Cognitive Walkthrough (See Addendum E)

The strength of a cognitive walkthrough is in determining learnability through exploration. Since this closely reflects the true environment in which PlantTracker® will be utilized – first-time users, infrequent repeat use, novices, browsing vs. search – it is a well-suited method of evaluation. Evaluators will be HCI experts. The prototype and the user group will be described to them. Evaluators will then be asked to fulfill the task of identifying a sun-loving plant by performing the following action steps:

1. Select the “Plant Parts” menu by tapping on it.
2. Select “Light Requirements” by tapping on it.
3. Narrow the light range by sliding the left icon to the right.
4. Zoom in by tapping on a highlighted area until an individual plant is discernible.
5. Select reading mode by tapping on the book icon.
6. Select a plant by tapping on the highlighted item and note the name.

The evaluators will then be asked to answer the following four questions for each step to build a believability story:

1. Will the user be trying to produce whatever effect the action has?
2. Will the user be able to notice that the correct action is available?
3. Once the correct action is found, will the user know it’s the right one?
4. After the action is taken, will the user understand the feedback given?

Testing Method 3 – Think Aloud (see Addendum F)

Users in the field will be asked to perform the think-aloud method of analysis. This type of analysis is especially useful in determining what prior knowledge a user brings when encountering a new system. Insights into users’ mental models can be obtained that can help see which relatively new small-screen and mobile computing paradigm conventions are already popular, and which are still not well-established. These evaluators will be given the following scenario:

You are standing in the Japanese Garden in front of a plant that interests you, and want to know its botanical name.

The prototype will then be handed to them with instructions to verbalize all thoughts as they are using the interface. Lapses of action and verbalizations will be cues to prompt the evaluator, encouraging them to continue thinking aloud.

This method will be used to observe:

1. What slips are made and how persistent and frequent they are, confirming or denying the potential modality problem.

2. What optional action steps are taken, and how persistently, pointing to gaps in the 7-stage execution/evaluation model.
3. How often the evaluator needs clarification.
4. Where eyes traveled, especially between virtual and real worlds.

The successfulness of PlantTracker® will be measured by performance: 85% of users must be able to successfully complete the task.

D. Implementation of the Prototype

PlantTracker® is written in ActionScript. Graphics were created in Adobe Illustrator and PhotoShop®. Animations were created with Macromedia Flash®. The file was saved in shockwave file format (swf).

E. Assessment

Expressed in terms of Norman's 7-stage model of execution and evaluation (*page 19*), slips and errors were a result of a wide gulf of evaluation. An immature prototype did not allow users to perceive a useful state after they executed an action.

Another stage in Norman's model at which error occurred was within the gulf of execution. Although all the actions were available (get a closer look, rollover to see what shows, tap on item for information), some *planned sequences* of actions were not anticipated. Thus, appropriate responses were not developed. By incorporating appropriate responses (e.g., "Would you like to zoom in for a better look?" when user is trying to access information on the crowded home screen), users might be assisted to formulate more efficient and useful action steps to accomplish their task. A summary of test results and their implications follows:

Heuristics Results

Currently, no HCI experts have submitted results using this method.

Cognitive Walkthrough Results

Currently, one HCI expert tested the prototype and submitted his results. Analysis will be done pending further cognitive walkthrough tests.

Think Aloud Results

Four end-users of various ages and nationalities tested the prototype — one was a teenager, three were in mid-40s. One was German, three were American. All were female. They possessed varying degrees of familiarity with computational devices from accessing the internet from a home computer to using a cell phone. Slips and errors that were observed are listed in order of appearance.

1. Forgetting “Welcome” information. Users dismissed “Welcome” screen information (brief overview of navigation, getting information and filtering) immediately after reading. In follow-up discussions, all users commented on the high level of clarity of instructions (*Figure 17*).

Implication: Explicit directions, even if brief, cannot be relied upon to impart incremental learnability. One possible explanation might be that the user does not need the information at this time, and therefore does not place a priority on remembering it. One possible solution might be to show the information within context of the user’s first need for it (as in an adaptive help system). Redundant verbal instructions and/or animations of the concepts might also help the retention of information. Also, mimizing the presentation to only a few icons or phrases might help.

Another implication might be that the user’s mental model derived from the “Welcome” screen instructions does not match the model on the interface. The system operates in either one of two modalities: navigation or reading. A separate component is the customizing capabilities offered through “Plant Parts,” accessible in either mode. The current graphic layout of the “Welcome” screen might mislead users into believing that there are three modes, none of which are mutually exclusive. The layout of the components of the interface screen might mislead users into believing there are two components available (Plant Parts and the reading mode), and that they are perhaps mutually exclusive of each other. Developing a metaphor would help apply mental models to the interface. Use of the design could then clarify the “Welcome” screen ambiguity.



Figure 17: “Welcome” screen shot (above) and Home screen shot (below).

2. Repeated tap on plant in zoom mode to retrieve plant information. In designing for this potential slip, an animation and light border were used to alert the user to the system's current mode and mode change. The animation of the border emanating from the book icon (instead of merely appearing in place) was used for two reasons: the user can blink or otherwise be momentarily distracted and not miss the mode change, and the learnability of the book tool can be reinforced. The light blue border was used because peripheral vision is sensitive to light, and thus can more readily distinguish this cue from its lightness rather than its hue (*Figure 18*).



Figure 18: Navigation mode screen shot (above) and reading mode screen shot (below).

Implication: The challenge in determining the severity of this problem was discovered through direct observation — a mature prototype might have rendered this problem not as severe. Users would have been forced into a different level of magnification each time they attempted to access plant info while in the wrong mode. This accurate feedback would have reinforced the importance of modality, possibly leading the user to more confidently or quickly explore other options.³³

Another solution might include combining gesture and object into one “syntax-free” interaction: a drag-and-drop book icon. Instead of forcing the user to make two explicit actions (one to change the mode, one to select the item) in an explicit order,

³³Dix, Alan, Janet Finlay, Gregory Abowd, Russell Beale. *Human-Computer Interaction*, 2nd Edition. Harlow, England: Prentice Hall Europe, 1998, pg. 138.

the user would drag the book icon onto the plant. This would eliminate an unnecessarily heavy cognitive load on the user.³⁴

A third solution might be to incorporate an adaptive help system. When users tap on the screen in more than one consecutive magnification, a dialog box can appear to ask if they want to zoom in or get information. This dialog box can cease to display after three or four exits from the read mode (implying, of course, that only three or four times of rehearsal would be needed to recall the necessity of mode change).

3. Using Plant Parts menu to identify a physically located object. Without a formal understanding of what task the users themselves were trying to accomplish (i.e., locate, identify, rank, compare, etc.), users were unclear as to how best to accomplish their task. They, therefore, defaulted to a search-type trial and error method that relied on the assumption that they *already knew* enough information about the plant (knowledge in the head) to obtain the rest of the information sought (upper screen shot). Since there are numerous categories from which to select in “Plant Parts,” numerous attempts were made to locate the plant (*Figure 19*).

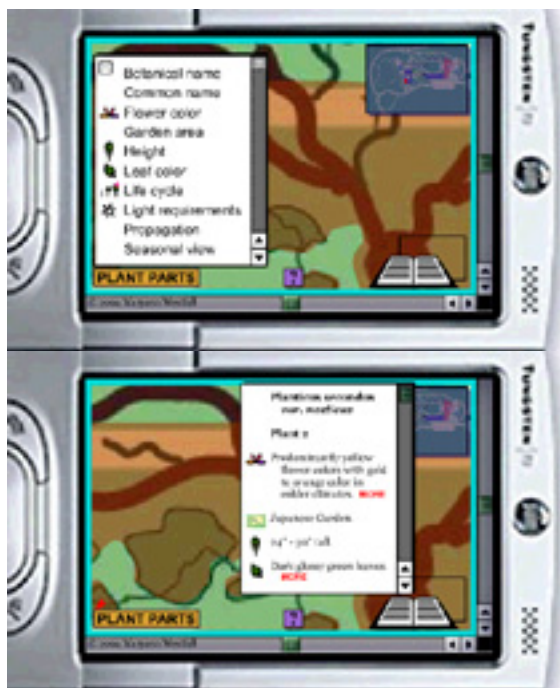


Figure 19: “Plant Parts” menu screen shot (above) and plant info screen shot (below).

Implication: This behavior — relying on knowledge in the head rather than knowledge in the world — suggests two things. First, that what was once naturally “intuitive” to an average person is quickly becoming replaced with a cultural default resulting from ubiquitous computing. Users did not necessarily think of

³⁴Hutchins, Edwin L., James D. Hollan and Donald A. Norman. “Direct Manipulation Interfaces.” *Human-Computer Interaction*, Volume 1, pg. 103. Hillsdale, NJ: L. Erlbaum Associates, 1985.

their physical relationship to the object as the best means of obtaining information (pick the plant to find its name), but rather going through an abstract remediated version of the object ([1] select a value [2] of a category [3] from a menu [4] of a device [5] to find a correlated value of the object). Secondly, it suggests that a Situated Action model would be the most productive to use in user testing (especially for mobile computing arenas).³⁵ If the users were in a garden (with a less-prominent computational component than in a lab), they may have relied less heavily on knowledge in the head, eliminating its disadvantage of assumptions. They would have been able to maximize their physical relationship to the object, and be encouraged to try a new way to gather information rather than relying on a familiar academic method. The challenge in using situated action would be in developing a detailed prototype with low-level specifications that may or may not be relevant to a user's "situated action" — a potentially substantial investment in resources.

Summary of Assessment

Slips in modality proved to be a critical issue in successfully using the interface. The slip was anticipated by users in reading mode who wanted to navigate. Instead, the slip in modality occurred before users ever entered reading mode. When zoomed in to maximum magnification, users simply expected that a tap on a plant would provide plant information. A combination of developing a more complete prototype with full zoom capabilities and error messages, and developing input that minimizes cognitive load by combining discreet, ordered steps into single object-actions might prove to correct many of the problems discovered through user testing.

³⁵Nardi, Bonnie A. *Studying Context: A Comparison of Activity Theory, Situated Action, and Distributed Cognition*. Cambridge, MA: MIT Press, 1996.

IV. Bibliography

Botanical and Industry Background

Better Homes and Gardens Plant Guide

(http://www.bhg.com/default.sph/garden_db.class?).

Complete Guide to Gardening, Better Homes and Gardens, pp. 75, 180, 229, 247, 267, 357, 360, 365. Des Moines, Iowa: Meredith Corporation, 1979.

FNC=Initialize__Ainit_garden_html).

Dioscorides, Pedanius. *De Materia Medica*. Turkey: circa 50 A.D.

Gale Business Resources, ©2002 Gale Group, "Arboreta and Botanical or Zoological Gardens," <http://www.galenet.com>. [SIC "Botanical and Zoological Gardens" from Statistic Universe].

Gale Business Resources, ©2002 Gale Group, "Yard and Garden Products," <http://www.galenet.com>. [SIC "Lawn and Garden Equipment" from Statistic Universe.]

Gale Business Resources, ©2002 Gale Group, "Retail Nurseries, Lawn and Garden Supply Stores," <http://www.galenet.com>. [SIC "Retail Nurseries and Garden Stores" from Statistic Universe].

Industry-Occupation Matrix. Bureau of Labor Statistics.

Missouri Botanical Garden's W3Tropicos

(<http://mobot.mobot.org/W3T/Search/vast.html>).

Nursery Retailer, February/March, 1999, p. 59. [SIC code 3524].

USDA, NRCS. *The PLANTS Database, Version 3.5*. Baton Rouge, LA: National Plant Data Center, 2002. (<http://plants.usda.gov>).

USDA, NRCS. 2002. The PLANTS Database, Version 3.5 (<http://plants.usda.gov>). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

U.S. Census Bureau, Census 2000.

U.S. Census Bureau, Statistical Abstract of the United States: 2000, Table No. 13.

Williams, Paul. *The Garden Color Book*. San Francisco, CA: Chronicle Books, 2000.

Weiss, Gaes and Shandor Weiss. *Growing and Using the Healing Herbs*. New York, NY: Rodale Press, Inc., 1985.

Form Factor

Dix, Alan, Tom Rodden, Nigel Davies, Jonathan Trevor, Adrian Friday and Kevin Palfreyman. "Exploiting Space and Location as a Design Framework for Interactive Mobile Systems." *ACM Transactions on Computer-Human Interaction ToCHI*, 7(3), September 2000, pp. 285 – 321. New York, NY: ACM Press, 2000.

Milojicic, Dejan S., Frederick Douglass and Richard Wheeler. *Mobility: Processes, Computers, and Agents*. Reading, MA: Addison-Wesley, 1999.

Nielsen, Jakob, editor. *Designing User Interfaces for International Use*. New York, NY: Elsevier Science Pub. Co., 1990.

- Nielsen, Jakob. *Designing Web Usability*. Indianapolis, IN : New Riders, 2000.
- Nielsen, Jakob and Elisa M. del Galdo, editors. *International User Interfaces*. New York, NY: Wiley Computer Publishing, John Wiley & Sons, 1996.
- Nielsen, Jakob. "Noncommand User Interfaces." *Communications of the ACM* 36(4), April '93, pp. 83 – 99. New York, NY: ACM Press, 1993.
<http://www.useit.com/papers/noncommand.html>.
- Rahman, Tarjin and Paul Muter. "Designing an Interface to Optimize Reading with Small Display Windows." *Human Factors* 41(1), pp. 106 – 117. Toronto, Canada: Human Factors and Ergonomics Society, 1999.
- Schilit, Bill. "User-Interface Design for Palm-Sized Computers." XeroxParc. XeroxParc, 1995. <http://sandbox.parc.xerox.com/parctab/csl9501/node4.html>.
- Solomon, James D. *Mobile IP: The Internet Unplugged*. Upper Saddle River, NJ.: PTR Prentice Hall, 1998.
- Stojmenovi, Ivan, editor. *Handbook of Wireless Networks and Mobile Computing*. New York, NY: Wiley, 2002.
<http://www.marcrettig.com/writings/rettig,SmallScreens.pdf>
<http://www-diglib.stanford.edu/~testbed/doc2/PowerBrowsing/>

Human-Computer Interaction

- Aoki, Paul M., A. Hurst and A. Woodruff. "Tap Tips: Lightweight Discovery of Touchscreen Targets." *Extended Abstracts, ACM SIGCHI Conf. on Human Factors in Computing Systems*, pp. 237 – 238. Seattle, WA: ACM SIGCHI Press, March 2001.
- Aoki, Paul M. and Allison Woodruff. "Improving Electronic Guidebook Interfaces Using a Task-Oriented Design Approach." *Proceedings of the 3rd ACM Conference on Designing Interactive Systems: Processes, Practices, Methods and Techniques*, pp. 319 – 325. New York City, NY: Xerox Parc (?), August 17 – 19, 2000.
- Buxton, W. "There's More to Interaction than Meets the Eye: Some Issues in Manual Input." *User Centered System Design: New Perspectives on Human-Computer Interaction*, pp. 319 – 337. Hillsdale, NJ: Lawrence Erlbaum Associates, 1986.
- Card, Stuart K., Thomas P. Moran and Allen Newell. *The Psychology of Human-Computer Interaction*, pp. 23 – 44. Hillsdale, NJ: L. Erlbaum Associates, 1983.
- Dix, Alan, Janet Finlay, Gregory Abowd, Russell Beale. *Human-Computer Interaction*, 2nd Edition. Harlow, England: Prentice Hall Europe, 1998.
- Hutchins, Edwin L., James D. Hollan and Donald A. Norman. "Direct Manipulation Interfaces." *Human-Computer Interaction*, Volume 1, pp. 331 – 338. Hillsdale, NJ: L. Erlbaum Associates, 1985.
- Inkpen, Kori, Kellogg S. Booth and Maria Klawe. "Interaction Styles for Educational Computer Environments: A Comparison of Drag-and-Drop vs. Point-and-Click. (Technical Report No. 96-17). Department of Computer Science, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada, 1996.

- MacKenzie, S., A. Sellen, and W. Buxton. "A Comparison of Input Devices in Elemental Pointing and Dragging Tasks." *Proceedings of CHI '91*, pp. 161 – 166. New Orleans, LA: ACM Press, 1991.
- Nardi, Bonnie A. *Studying Context: A Comparison of Activity Theory, Situated Action, and Distributed Cognition*. Cambridge, MA: MIT Press, 1996.
- Norman, Donald A. *The Design of Everyday Things*. New York, NY: Doubleday, 1990.
- Pascoe, Jason, Nick Ryan, David Morse. "Using While Moving: HCI Issues in Fieldwork Environments." *ACM Transactions on Computer-Human Interaction ToCHI*, 7(3), September 2000, pp. 417–437. New York, NY: ACM Press, 2000.

Information Visualization

- Card, Stuart, Jock Mackinlay and Ben Shneiderman. *Readings in Information Visualization: Using Vision to Think*. San Francisco, CA. Morgan Kaufman, 1999.
- Spence, Robert. *Information Visualization*. Harlow, England: ACM Press, 2001.
- Tufte, Edward. *Envisioning Information*. Cheshire, CT: Graphics Press, 1990.
- Tufte, Edward. *The Visual Display of Quantitative Information*. Cheshire, CT: Graphics Press, 1983.
- Ware, Colin. *Information Visualization : Perception for Design*. San Francisco, CA: Morgan Kaufmann, 2000.

Mixed Reality

- Blechschiemied, Heiko, Daniel Holweg, Arne Schilling and Dr. Uwe Jasnoch. "Mobile Tourism – New GIS-Based Applications at the CeBIT Fair." *Proceedings at the CeBIT Fair*, pp. 17 – 19. Hannover, Germany: CeBIT, 2003.
- Feiner, Steven. "Taking It to the Streets: How Virtual Reality Can Change Mobile Computing." *Proceedings from IEEE Virtual Reality 2003 (VF'03)*. Place?: Pub?, 2003.
- Grönbæk, Kaj, Jannie F. Kristensen, Peter Ørbæk and Mette Agger Eriksen. "Physical Hypermedia: Organising Collections of Mixed Physical and Digital Material." *Proceedings of the Fourteenth ACM Conference on Hypertext and Hypermedia*, pp. 10 – 19. New York, NY: ACM Press, 2003.
- Milgram, Paul and Fumio Kishino. "Taxonomy of Mixed Reality Visual Displays." *IEICE Transactions on Information and Systems*, Vol. E77-D, No. 12, pp.1321 – 1329, Dec. 1994. Tokyo, Japan: The Institute of Electronics, Information and Communication Engineer, 1994.
- http://vered.rose.utoronto.ca/people/paul_dir/IEICE94/ieice.html.
- Romero, Luis and Nuno Correia. "HyperReal: a Hypermedia Model for Mixed Reality." *Proceedings of the Fourteenth ACM Conference on Hypertext and Hypermedia*, pp. 2 – 9. New York, NY: ACM Press, 2003.

Sinclair, Patrick, Kirk Martinez, David E. Millard and Mark J. Weal. "Links in the Palm of Your Hand: Tangible Hypermedia Using Augmented Reality." *Proceedings of the Thirteenth ACM Conference on Hypertext and Hypermedia*, pp. 127 – 136. New York, NY: ACM Press, 2002.
Xerox Parc electronic guidebook, <http://www2.parc.com/csl/projects/guidebooks>.

Tracking Technology

Azuma, Ronald T. "The Challenge of Making Augmented Reality Work Outdoors." *Mixed Reality: Merging Real and Virtual Worlds*, pp. 379 – 390. London, UK: Springer-Verlag, 1999.

Flintham, Martin, Steve Benford, Rob Anastasi, Terry Hemmings, Andy Crabtree, Chris Greenhalgh, Nick Tandavanitj, Matt Adams and Ju Row-Farr. "People at Leisure: Social Mixed Reality." *Proceedings of Conference on Human Factors and Computing Systems*, pp. 569 – 576. New York, NY: ACM Press 2003.

Holweg, Daniel, Uwe Jasnoch and Ursula Kretschmer. "GEIST – Outdoor Augmented Reality in an Urban Environment." *Computer Graphik*, Issue 6, Vol. 14, pp. 5 – 6. Darmstadt, Germany. INI-GraphicsNet, 2002.
http://www.inigraphics.net/publications/topics/2002/issue6/6_02a01.pdf.

Kaplan, Elliott D., editor. *Understanding GPS: Principles and Applications*. Norwood, MA: Artech House, Inc., 1996.

Karagiozidis, Michalis, Dimitris Xenakis, Athanasios m. Demiris and Nikolaos Ioannidis. "LoVEUS: Software Architecture." *CeBIT Fair*.
<http://loveus.intranet.gr/>.

Reitmayr, Gerhard and Dieter Schmalstieg . "Location-Based Applications for Mobile Augmented Reality." *Proceedings of the Fourth Australian User Interface Conference on User Interfaces 2003* , volume 1, pp. 65 – 73. Darlinghurst, Australia, Australia: Australian Computer Society, Inc., 2003.

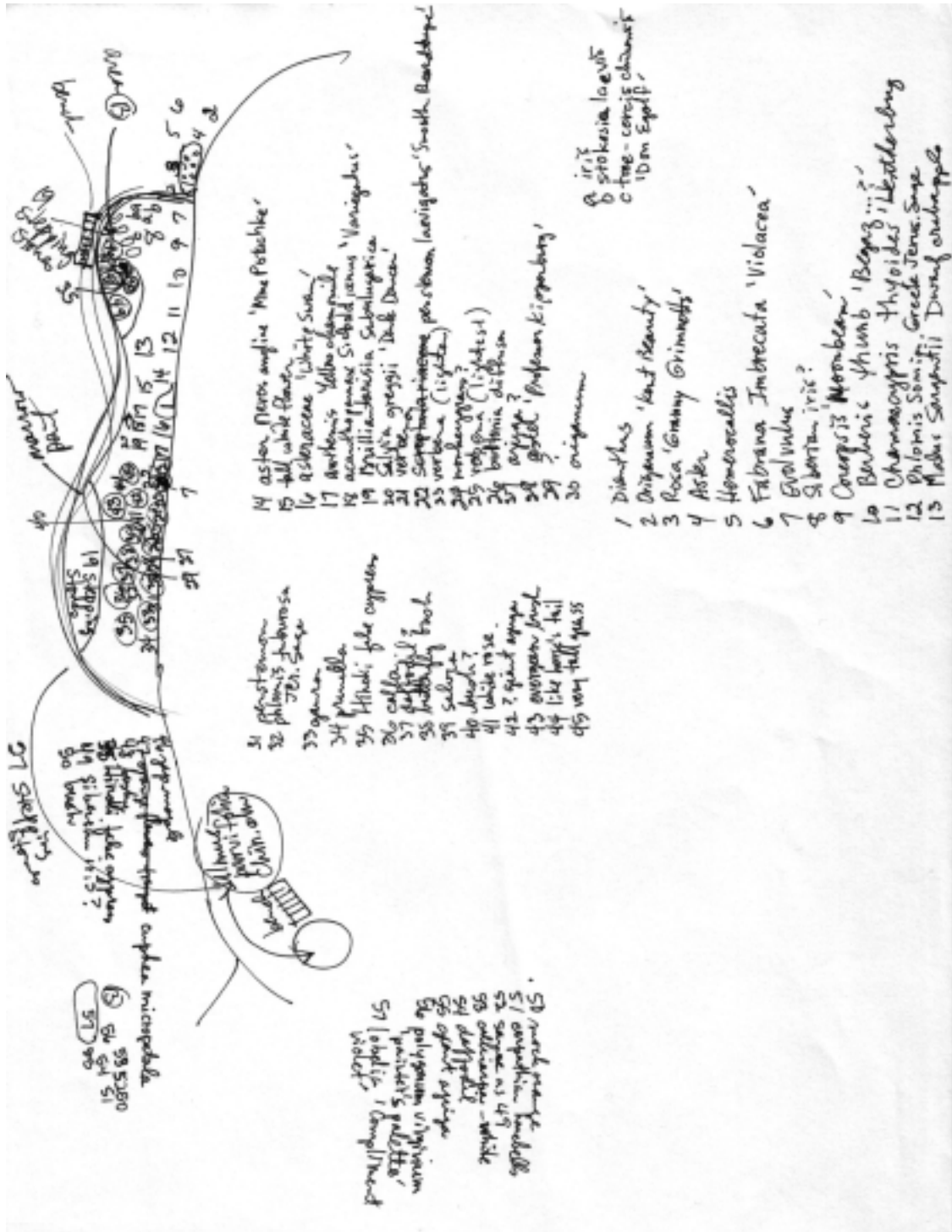
Sukaviriya, Noi, Mark Podlaseck, Rick Kjeldsen, Anthony Levas, Gopal Pingali and Claudio Pinhanez. "Augmenting a Retail Environment Using Steerable Interactive Displays." *Proceedings from CHI '03 Conference on Human Factors and Computing Systems*, pp. 978 – 979. New York, NY: ACM Press, 2003.

Trimble. "All About GPS Tutorial." *Trimble Navigation website*. Sunnyvale, CA. Trimble Navigation Limited, 2003. <http://www.trimble.com/gps/index.html>.

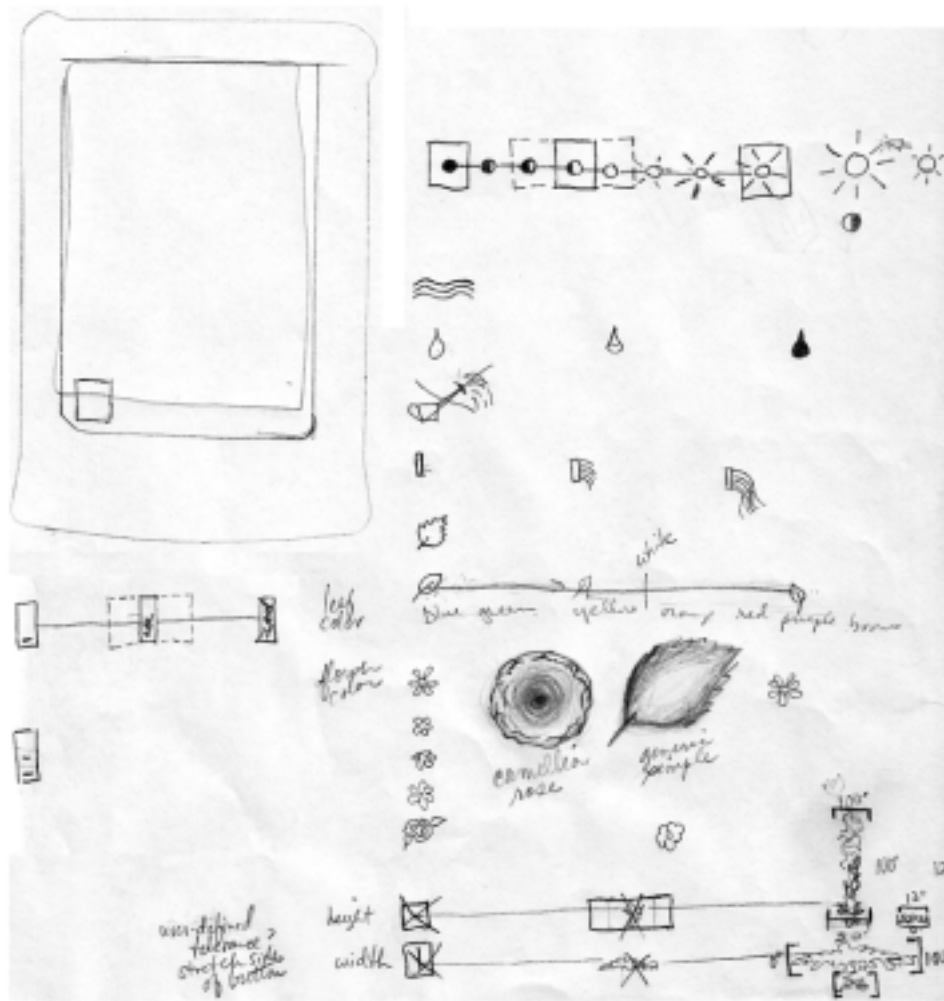
Thomas, Bruce, Ben Close, John Donoghue, John Squires, Phillip De Bondi and Wayne Piekarski. "First Person Indoor/Outdoor Augmented Reality Application: ARQuake." *Personal and Ubiquitous Computing*, Volume 6, Issue 1, pp. 75 – 86. London, UK: Springer-Verlag, 2002.
<http://gps.faa.gov/programs/nas/multi-center-text.htm>.
<http://users.erols.com/dlwilson/gpswaas.htm>.
<http://www.canyouseemenow.co.uk> - accessed 1st Jan 2003.
<http://www.cetusgps.dk/>.

http://www.ewh.ieee.org/soc/aess/plns/content_pages/history.html.
<http://www.gpsinformation.org/dale/dgps.htm>.
<http://www.navcen.uscg.gov/dgps/ndgps/default.htm>.
<http://www.ncgia.ucsb.edu/ncrst/resources/easyread/GPS/first.html>.
<http://www.tfhrc.gov/library/congress/congress.htm>.
<http://www.usg.edu/admin/comm/geosci/GISsurvey02.pdf>.

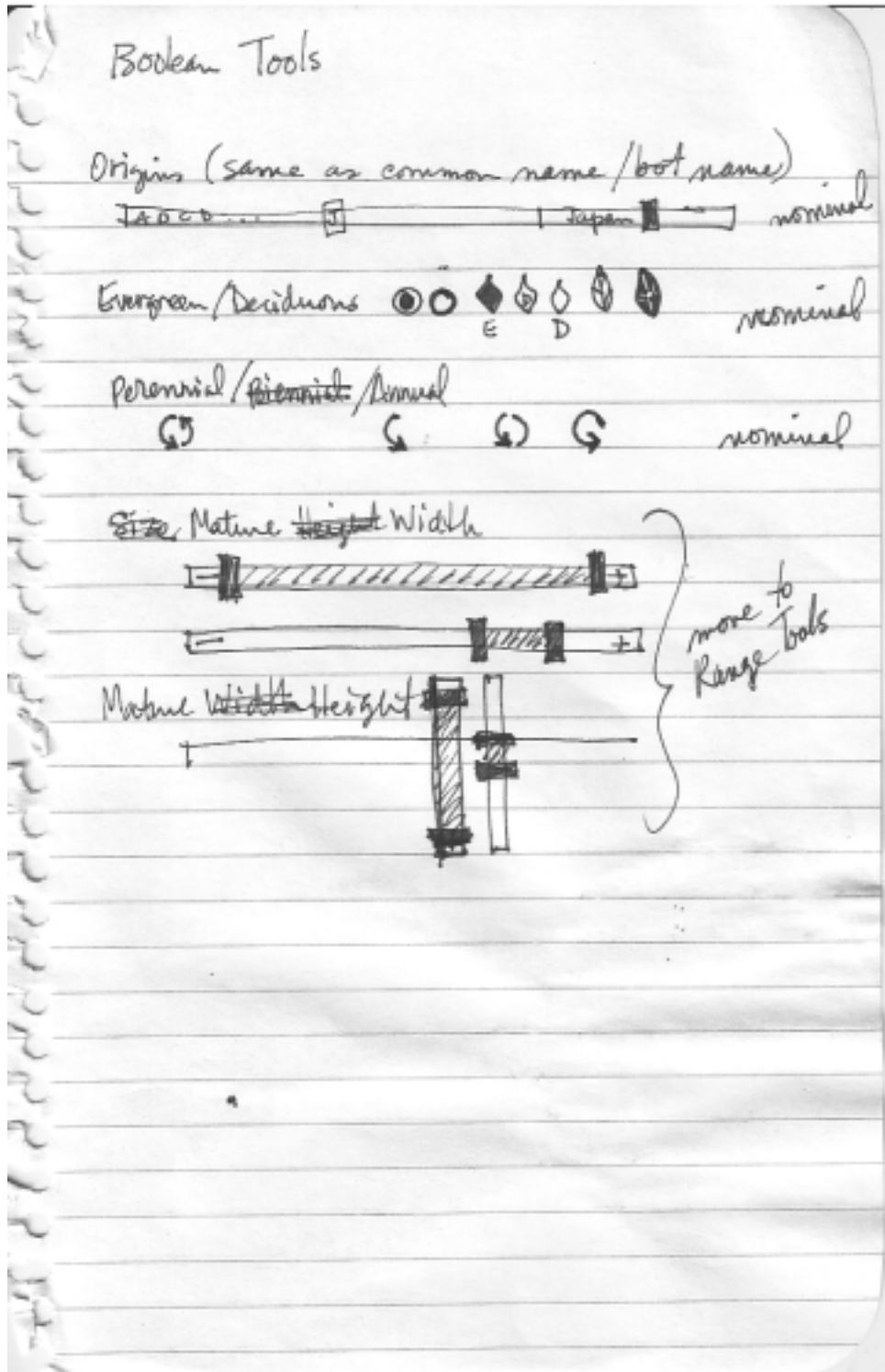
Addendum A – Sketch of Data-rich Unit-sized Area of Garden



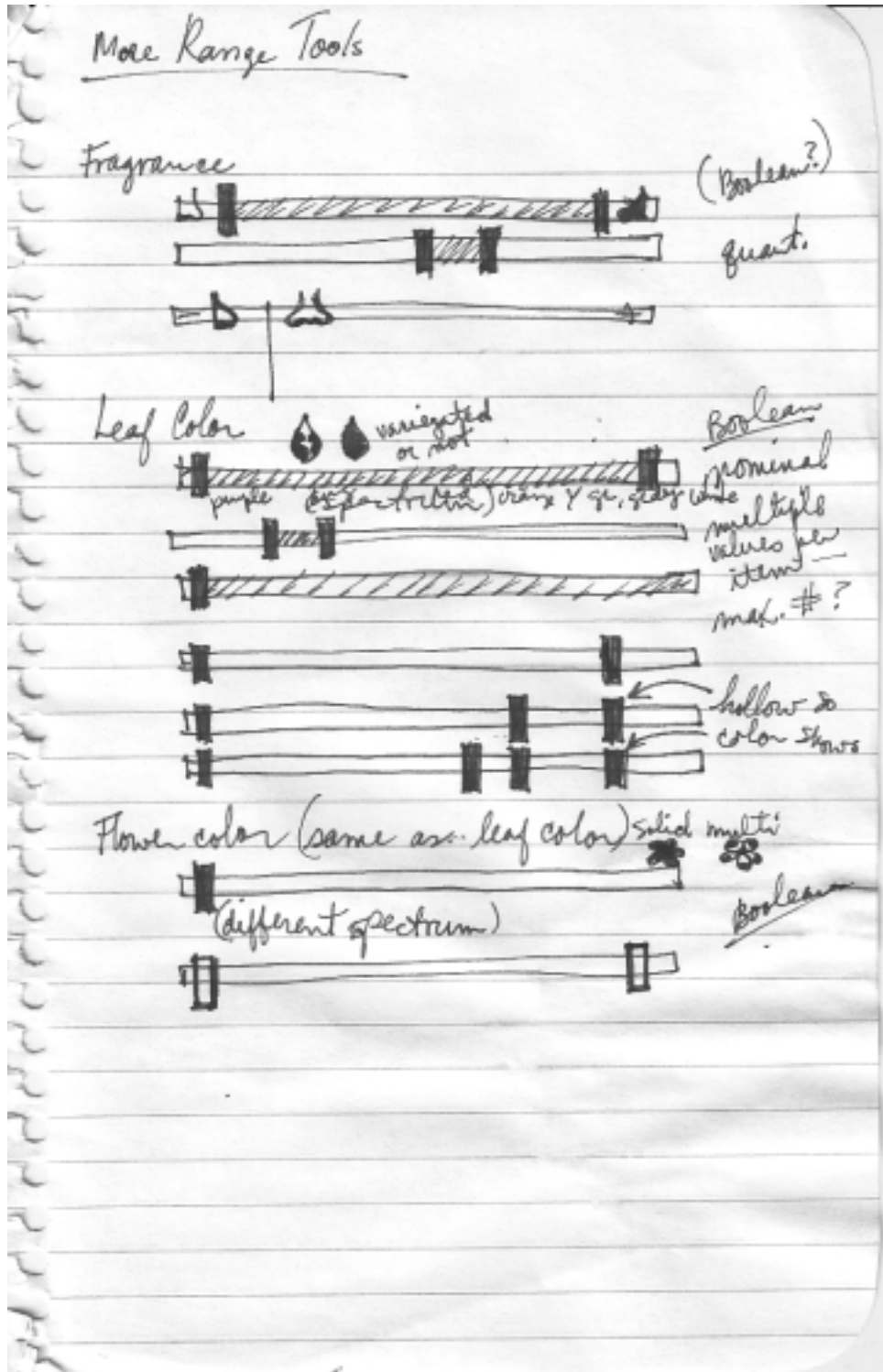
Addendum B — Sketches of Graphics and Animations



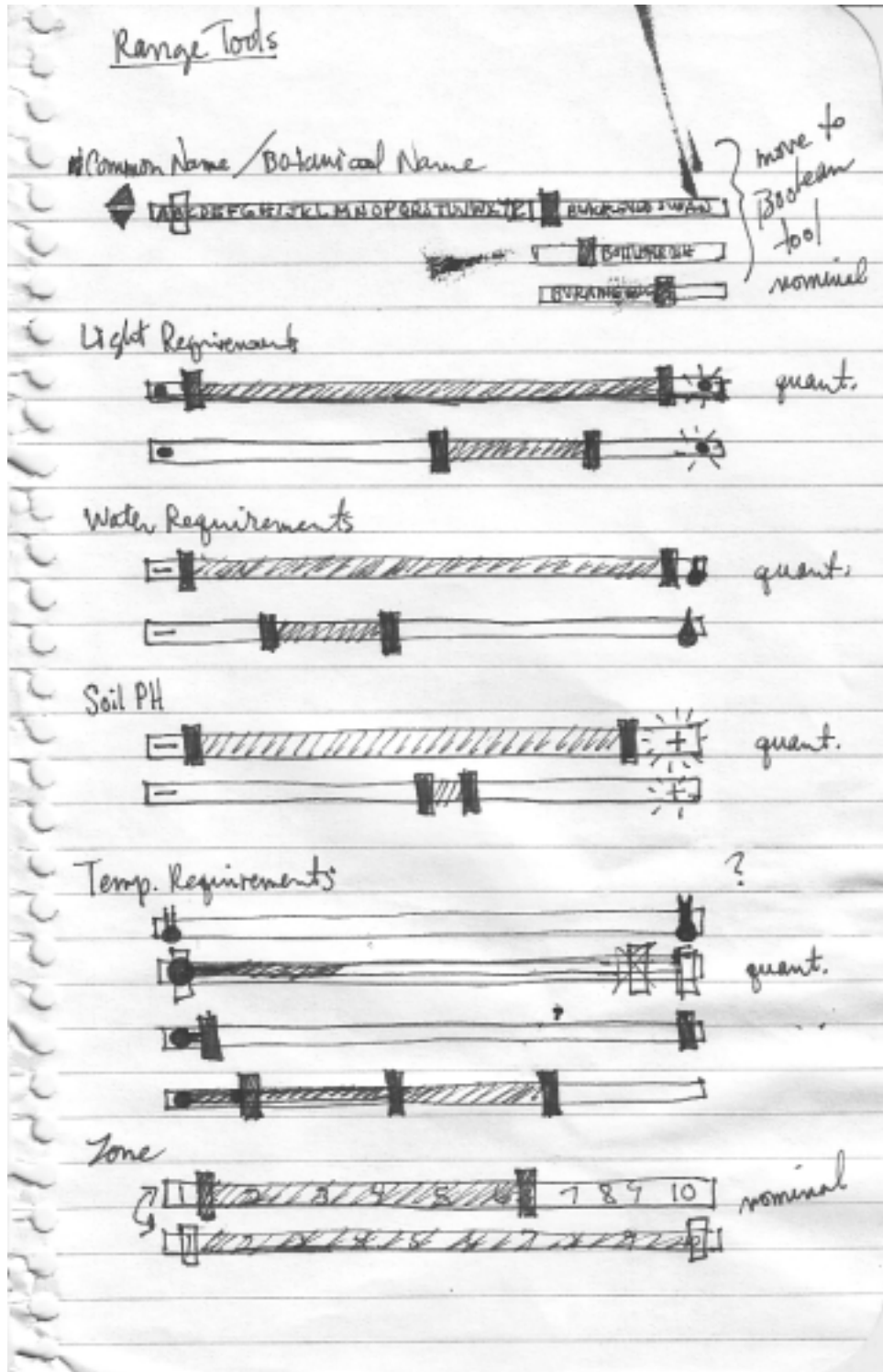
Addendum B (cont.) — Sketches of Graphics and Animations



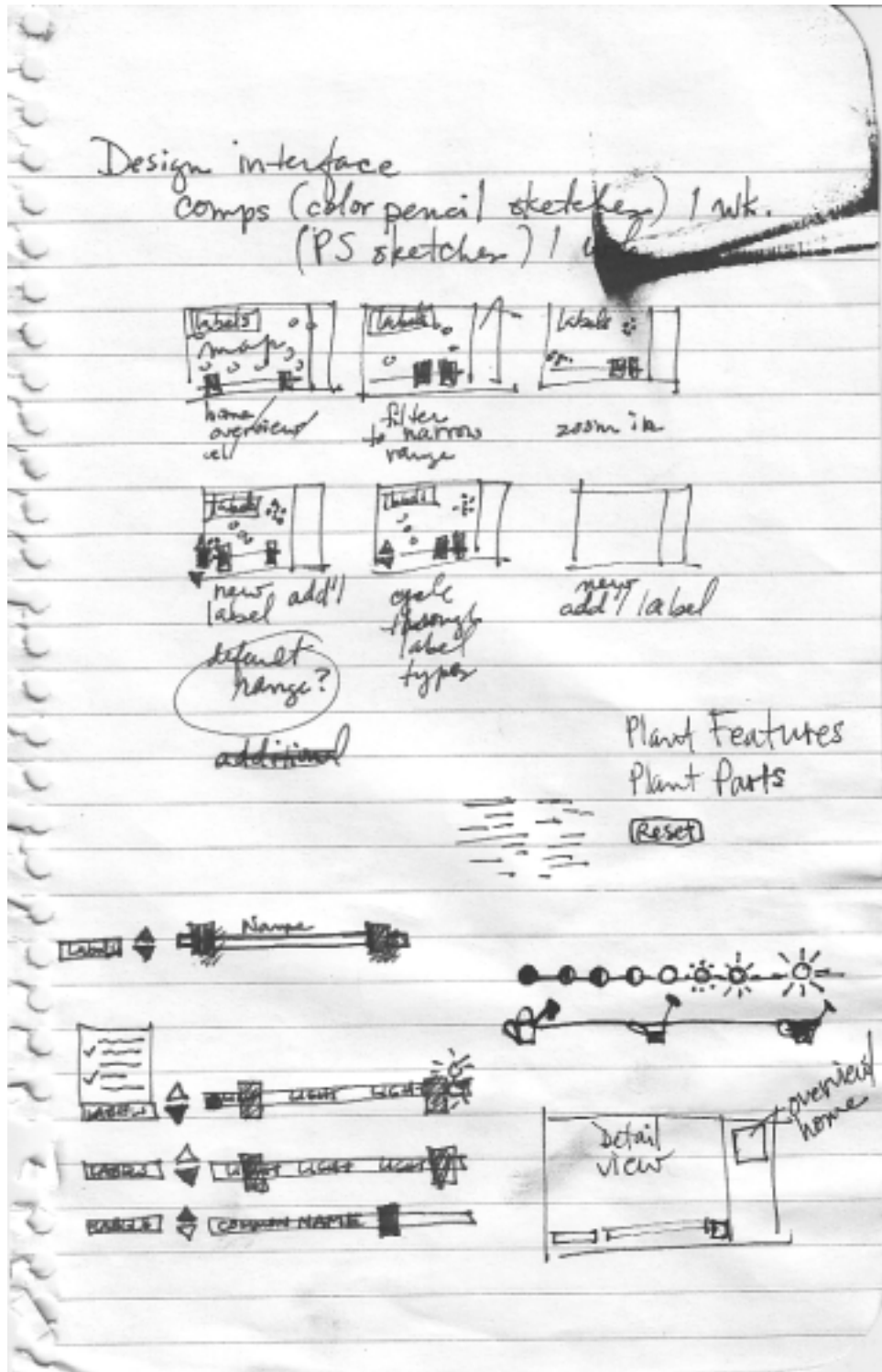
Addendum B (cont.) — Sketches of Graphics and Animations



Addendum B (cont.) — Sketches of Graphics and Animations

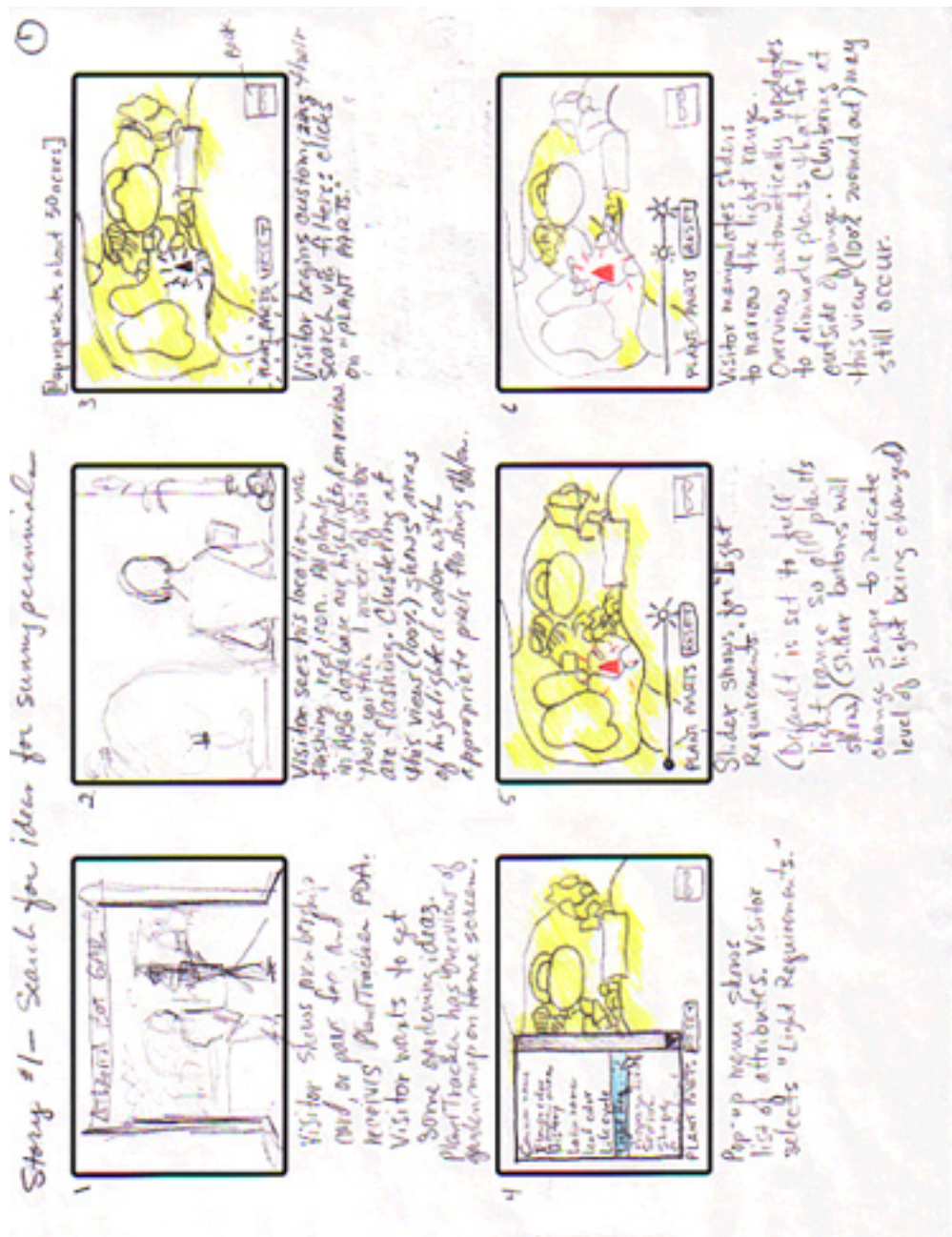


Addendum B (cont.) — Sketches of Graphics and Animations



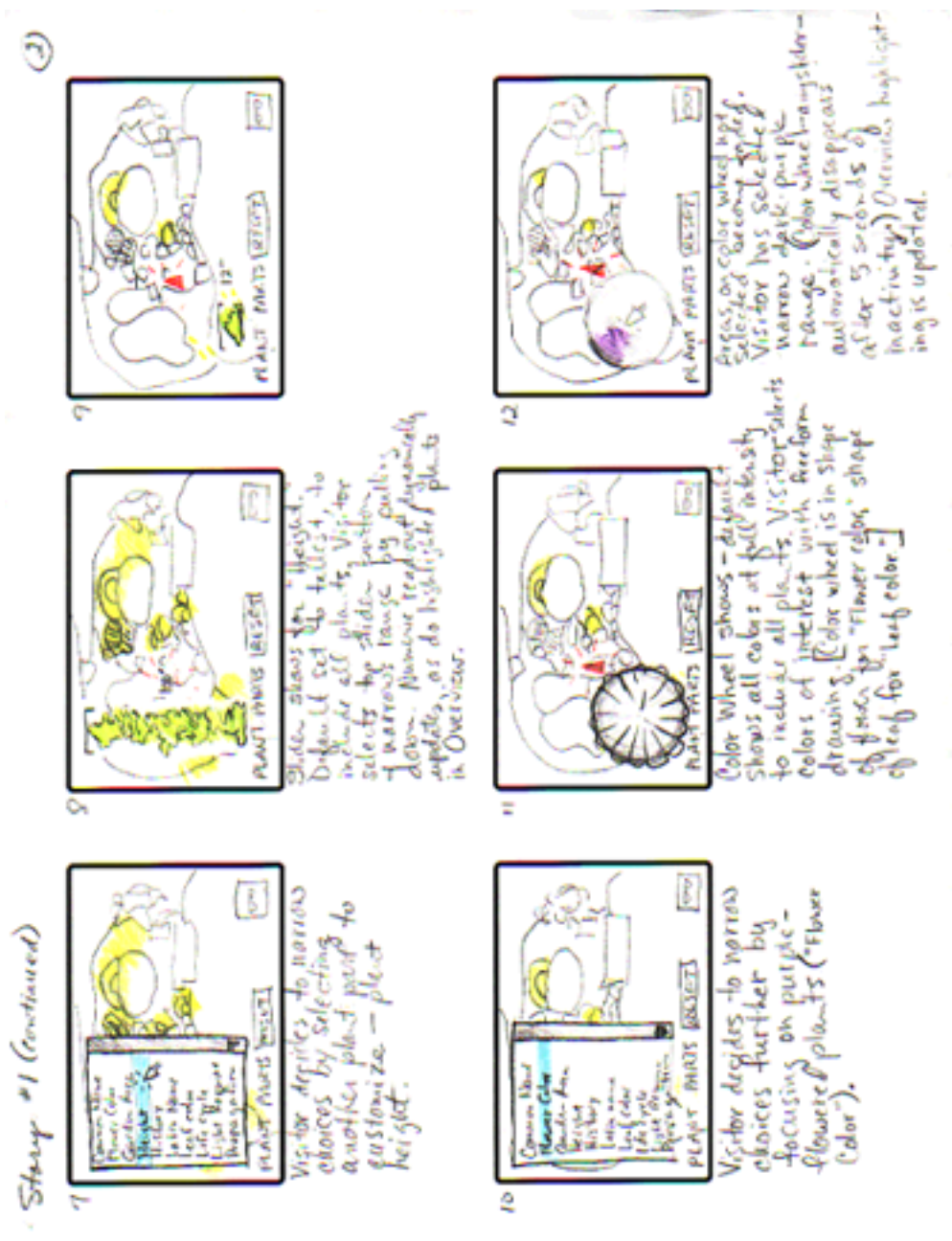
Addendum C – Storyboards

Storyboard #1: Searching for Ideas on What Sunny Perennials to Plant



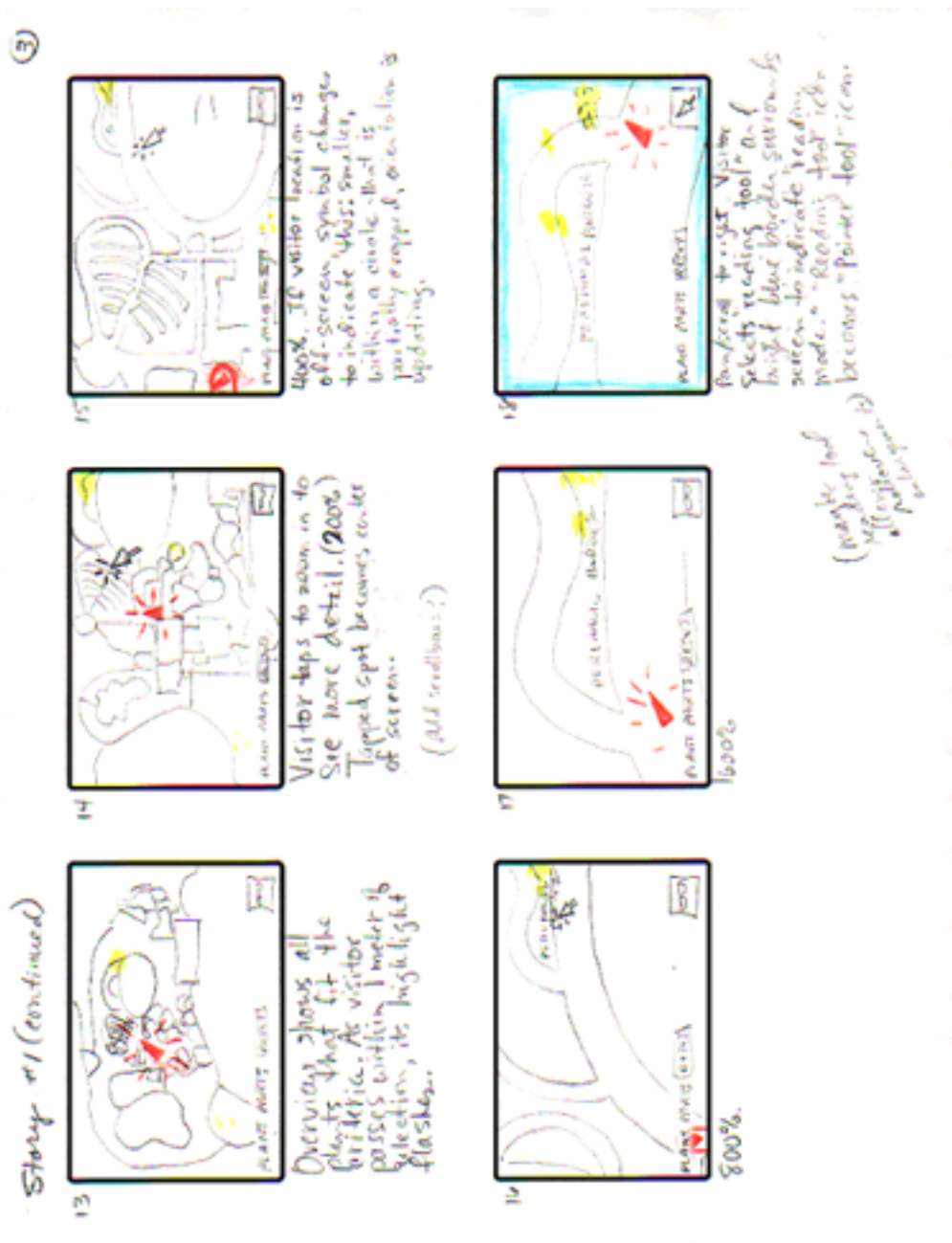
Addendum C – Storyboards

Storyboard #1: Searching for Ideas on What Sunny Perennials to Plant



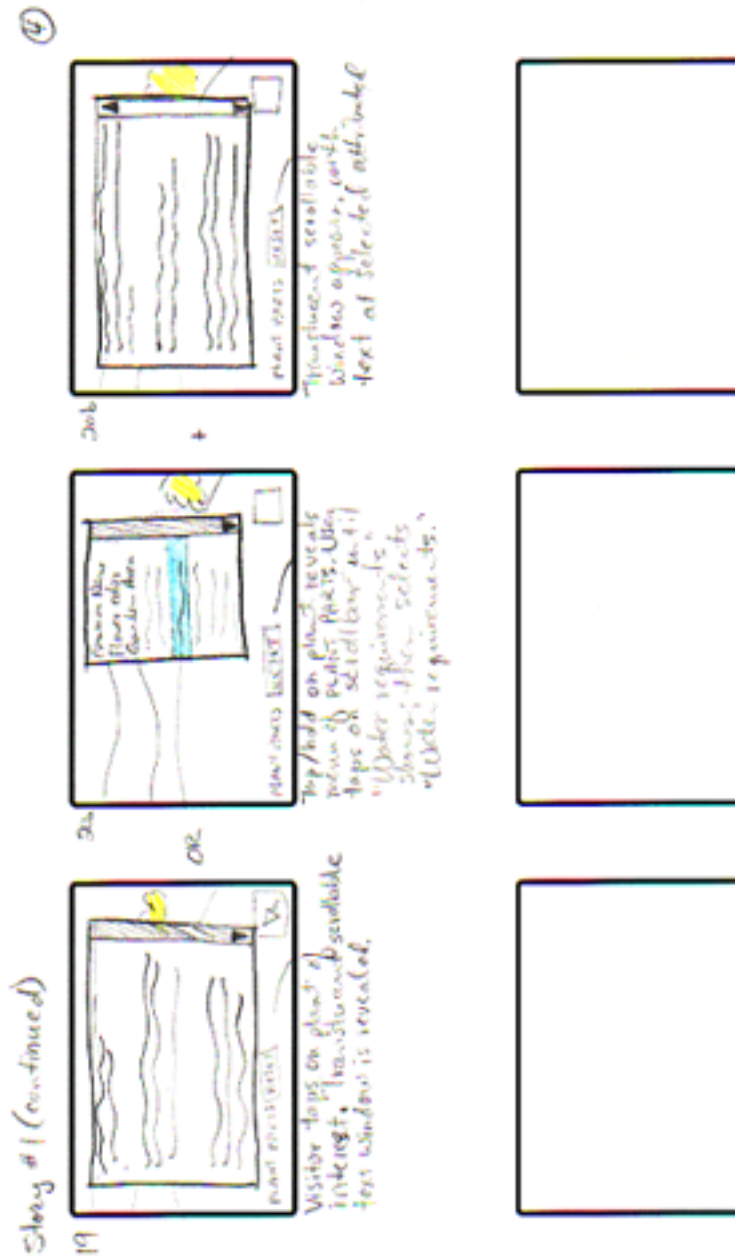
Addendum C – Storyboards

Storyboard #1: Searching for Ideas on What Sunny Perennials to Plant



Addendum C – Storyboards

Storyboard #1: Searching for Ideas on What Sunny Perennials to Plant





Addendum C (cont.) – Storyboards

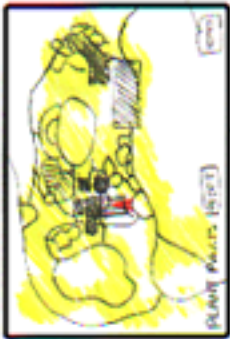
Storyboard #2: Browsing the Garden Grounds


Storyboard #2 - Browsing the garden grounds


①


1

 Visitor shows membership card, or pays fee, and receives brief plant Tracer, PPA. Visitor is visiting professor to Caltech and is killing some spare time.

2

 Visitor sees his location via flashing red icon. All plants in ABBG database are highlighted, those within 1 meter of visitor are flashing.

3

 As visitor interacts through gardening device about position & orientation plants which are highlighted on screen. Plant as visitor passes within 1 meter.

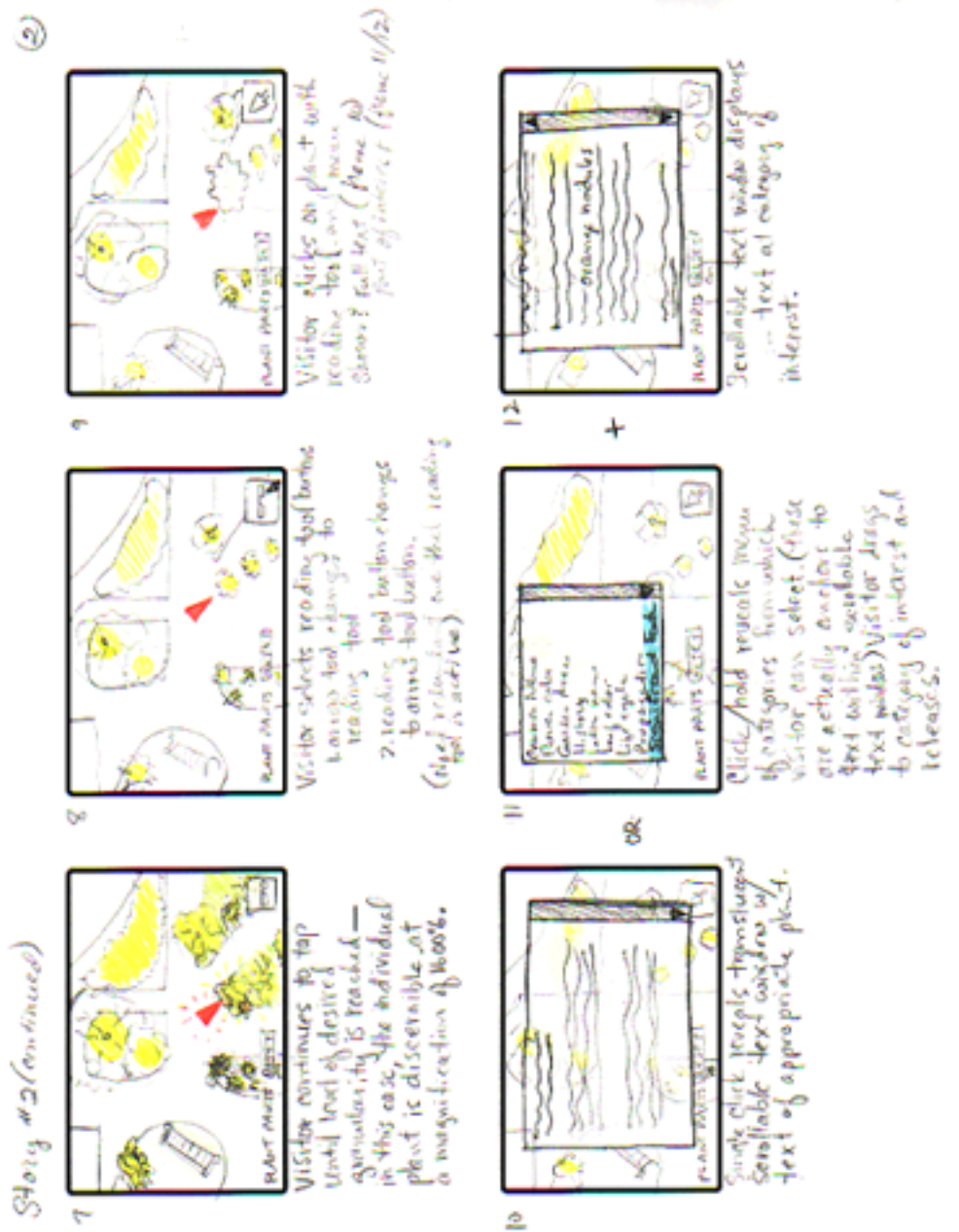
4

 Visitor sees an interesting plant, and wants more information than just name — wants to know what those orange nodules are.

5

 Visitor looks at device, and taps on flashing red icon to get a closer look.

6

 Since visitor is in "pointer" mode (default) view zooms in 200%. Tap of spot becomes center of screen. Plant within 1 meter of visitor continue to flash.

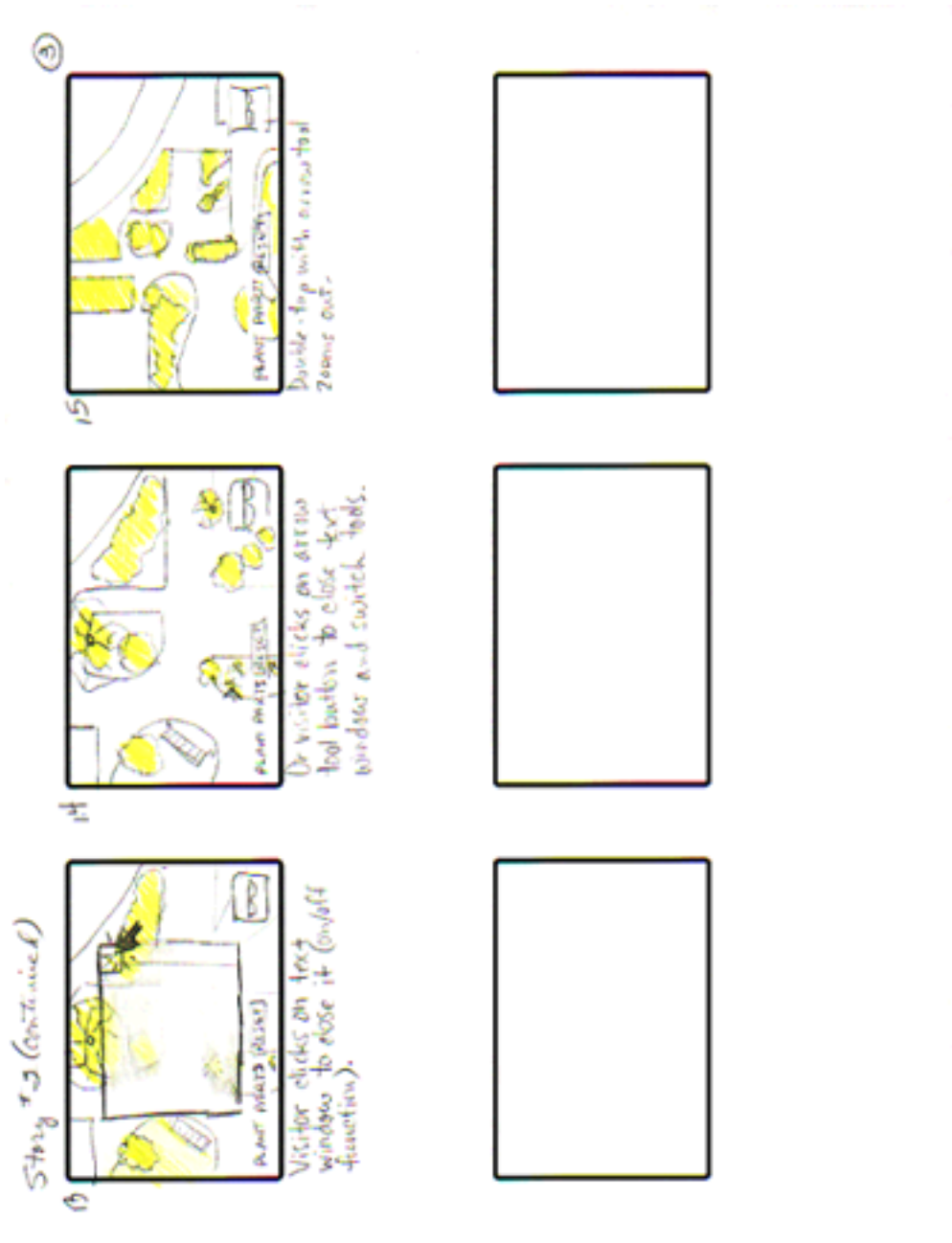
Addendum C (cont.) – Storyboards

Storyboard #2: Browsing the Garden Grounds



Addendum C (cont.) – Storyboards

Storyboard #2: Browsing the Garden Grounds



Addendum D – Heuristics Evaluation Form

Name of Evaluator _____

Date/Time _____

Key: 0 = least, 4 = most

Assuming you find problems, rate: Frequency Impact Persistence

1. Visibility – persistent and appropriate feedback in reasonable time.

2. Match Between System and the Real World – presents expected information, in layman’s terms, accessible through a logical sequence of actions.

3. User Control and Freedom – easy recoverability.

4. Consistency and Standards – within the application and amid popular convention.

5. Error Prevention – anticipating all possible uses and user methods.

6. Recognition rather than Recall – recognize objects, options and available actions.

Comments: _____

Addendum E – Cognitive Walkthrough Evaluation Form

Name of Evaluator _____

Date/Time _____

Task: Identify a sun-loving plant.

1. Select the “Plant Parts” menu by tapping on it.
2. Select “Light Requirements” by tapping on it.
3. Narrow the light range by sliding the left icon to the right.
4. Zoom in until an individual plant is discernible by tapping on corresponding map area.
5. Select reading mode by tapping on book icon.
6. Select a plant by tapping on the highlighted item, and note the name.

Answer the following four questions for each step specified above to build a believability story. Use the rubric below to record your answers.

1. Will the user be trying to produce whatever effect the action has?
2. Will the user be able to notice that the correct action is available?
3. Once the correct action is found, will the user know it’s the right one?
4. After the action is taken, will the user understand the feedback given?

Rubric (Y=yes; N=no)

	#1	#2	#3	#4
1. Select the “Plant Parts.”				
2. Select “Light Requirements.”				
3. Narrow the light range by sliding the left icon to the right.				
4. Zoom in until an individual plant is discernible.				
5. Select reading mode by tapping on book icon.				
6. Select a plant by tapping on highlighted item; note the name.				

Addendum F – Think Aloud Evaluation Form

Name of Evaluator _____

Date/Time _____

Task:

You are standing in the Japanese Garden in front of a plant that interests you. You attempt to find out its botanical name.

1. What slips are made and how persistent and frequent they are, confirming or denying the potential modality problem.

2. What optional action steps are taken, and how persistently, pointing to gaps in the 7-stage execution/evaluation model.

3. How often the evaluator needs clarification.

4. Where eyes traveled, especially between virtual and real worlds.

Inquiry #1 _____

Inquiry #2 _____

Inquiry #3 _____

Task successfully concluded Y N Time (min:sec or N/A) _____