Making Game Design as Easy as Gaming: Creating an Administrative Interface for the Makahiki Framework

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Abstract

The usability of an application is a measure of how effectively it can be used to perform the tasks it was designed for in its target environment. A user interface the toolbars, menus, and other elements that control an application determines how quickly and correctly users can complete tasks. Makahiki is an application framework for designing serious games (games which teach a serious subject) focused on energy conservation, recycling, and clean energy issues. A problem with the current iteration of Makahiki is that creating competitions in its administrator interface is time-consuming. To identify the reasons for this problem, I will work with the Makahiki development team to distribute surveys to identify usability issues. For the first survey, University of Hawai'i at Mānoa students will configure Makahiki for a course assignment, self-report the time required for each part of the configuration, and describe usability problems. I will develop a design tool that will address these problems. After the design tool is completed, some of the first surveys questions will be reused with a second group of test subjects, comparing their performance with the design tool against the first groups performance with the original application on a subset of the same tasks. This will determine if configuration times decreased and the usability issues of the original application were addressed by the redesign. The collection of usability data and the creation of the design tool will address Makahikis usability problems while enhancing the understanding of how user interface design styles affect usability.

1. Introduction

The goal of this project is to improve the usability of the Makahiki serious game design framework, a software application which provides tools and activity modules that can be used to create games which educate players about sustainability and renewable energy issues. Makahiki also tracks player participation and point earnings from each activity and awards prizes based on the criteria of the contest administrators. Though Makahiki has been deployed to support sustainable games in the past, a major issue preventing it from achieving wider use is the complexity of creating a functioning game instance in its current user interface. I will implement a ”design tool” addition to Makahiki which will attempt to streamline the setup process based on the configuration problems identified by user-submitted surveys and blog entries. After the completion of a stable version of the design tool, a second, separate sample of users will submit surveys to identify problems in the usability of the design tool. This will indicate the degree to which the design tool addressed the problems that the first group of users identified in the Makahiki configuration process. This project will improve the understanding of the relative usability of different user interface styles and improve the usability of a product that helps people educate others about sustainability.

1.1. Overview of Usability and HCI

The design of user interfaces falls within the domain of human-computer interaction, or HCI. According to the Association for Computing Machinery (ACM), HCI is the study of the design, evaluation, and implementation of computer systems that are designed to interact with humans [1]. The ACM committee of Hewett et al. defined user interface elements and dialogue interaction techniques to include icons, menus, forms, and speech and video input and output methods through which a user interacts with an application. The ACM also noted that the quality of a user interface had become a more important factor in the sales of an application over time [1]. User interface design is important in software engineering because the clarity or obtuseness of an application plays a large role in determining how useful it is and how useful customers perceive it to be.

1.1.1. User Interfaces and Usability.

It is generally agreed that an interfaces usability is evaluated based on the ease or difficulty with which it can be used to perform the tasks that its application was designed for, in the environment it was designed for. The level of difficulty is dependent on how well the interface satisfies its users’ needs in addition to environmental constraints [2], [1]. This perception is dependent on the user's qualitative perceptions of the system and the processes required to interact with it via the interface [3]. These perceptions can result in more difficult systems being rated as less useful [4]. The usability of an application is heavily dependent on how easy the application's user interface is to use.

1.1.2. Interface Usability and Productivity.

The design of a user interface can have a significant effect on the productivity and accuracy of its users. McFarlanes study found that the group which was randomly interrupted by the user interface and forced to deal with the interruptions immediately had the highest number of key-pressing errors and the greatest number of incorrect actions in the interrupting task. This group performed worse than the group interrupted at regular intervals, the group allowed to delay their interruptions, and the group for which a scheduling program delayed interruptions until the main workload decreased [5]. Fang and Holsapple's study of website user interfaces found that a user interface with options organized by highest frequency of use was correlated with users completing tasks more quickly and correlated with a higher ratio of correct answers to incorrect answers, as compared to a user interface in which options were organized only by subject [2]. In addition, the evaluation by Wanderer et al. of two graphical interfaces for an anesthesia management system found that the interface which was redesigned to include color-coded feedback and context-sensitive menu items required fewer steps to complete medical documentation and had higher accuracy [6]. In both of these studies, differences in the design of an interface produce significant differences in accuracy and speed, which affect the productivity of an application's users. This means that it is possible that changing the design of a user interface can significantly increase the productivity of its users. These studies confirm that differences in the design of a user interface have been found to be correlated with statistically significant differences in a user's perceived experience with an application and in a user's actual performance with it.

1.2. Gamification and Serious Games

Makahiki is a framework for designing "serious games" which teach players about sustainability using the practices of gamification. Based on Deterding et al.'s definition of a game as play structured by rules and competition in pursuit of a goal, gamification is defined as the use of elements of game design for non-game elements of any digital or physical application or product [7]. Within the game industry, "gamification" refers to the increasing adoption and use of video games and video game-like applications in daily life, or to the idea that game elements can be used to make non-game products and services more engaging to consumers [7]. In addition, a serious game is any game which uses game elements, mimics the structure of a game, but is not designed for entertainment purposes. Game elements can include badges, leader boards, levels, and other interface design elements often associated with games. Serious games have been used in education and military training programs for several millennia, but only became widely used during the twentieth century [7]. Makahiki is a tool for creating serious games that educate players about sustainability.

1.2.1. Makahiki as a "Serious Game" Framework.

The goal of Makahiki as a serious game framework is to allow the designers of sustainability challenges to create competitions which increase players' knowledge of issues related to renewable energy while incentivizing the development of sustainable habits. The developers of Makahiki were motivated by a desire to reduce dependence on oil by educating players about the potential of renewable energy, stating that "Moving away from petroleum involves technological, political, and social changes, requiring citizens to not only think differently, but behave differently with respect to energy policies, methods of generation, and their own consumption [8]." Makahiki evaluates the performance of players and teams by measuring team energy use against predefined baselines, tracking user-earned points from activities, and tracking the activity participation percentages of individual teams.

1.2.2. Overview of Makahiki Functionality.

The Makahiki framework is a software application designed to collect power and energy consumption data from sensors installed within a buildings electrical grid [9]. Challenge administrators expressed concerns about the high amount of time required to create a sustainability competition in Makahikis administrative user interface. As a result, this project will modify the Makahiki framework's administrative user interface in order to address these concerns. Makahiki provides tools and a library of sample activities for creating and managing sustainability competitions. This project seeks to use user feedback as guidance for three tasks which will improve the Makahiki system: identification of current problems with the method of setting up a competition, modification of Makahiki to address the problems, and comparison of users experiences with the old and new user interfaces to determine if the modifications resulted in significant improvements to the system.

1.2.2.1. Responsibilities of Makahiki-Based Challenge Administration.

Challenge administrators are responsible for configuring and managing game widgets through Makahiki's web browser-based user interface. Each widget is a software module which provides in-game functionality such as scoreboards, energy use displays, user activity submissions, the Smart Grid Game widget that links users to activity pages, or raffle prize allocation [9]. This incorporation of game-like elements such as a points system, statistical performance tracking, and physical prizes in the pursuit of environmentalist goals is what makes Makahiki useful for creating a "serious game." The system can be heavily customized by administrators who are willing to put in the time required to read the documentation. However, for administrators who only want to change a few settings, creating a design tool that provides shortcuts to the most frequently used configuration settings or otherwise provides assistance to new administrators would be useful. This project seeks to determine the usability issues identified by users of the Makahiki system and provide additions to Makahiki which address those issues.

1.2.2.2. Makahiki, the Kukui Cup, and Other Sustainability Challenges in Hawaii.

By improving the usability of Makahiki, this project has the potential to make Makahiki usable by and usable for a wider audience of players and event organizers. Since 2011, the Makahiki framework has been used to manage the Kukui Cup competition at the University of Hawaii at Mnoa. The Kukui Cup is an energy conservation and sustainability competition that takes place in the first-year student dormitories at the University. Using a server running the WattDepot power meter data collection software, Makahiki gathers data from the power meters that have been installed in the central electrical panels on each floor, sampling data at regular intervals. Points are awarded to floors for low energy consumption and to individual players for earning points through the completion of tasks in the Smart Grid widget [10]. The annual cycling-out of the dormitories' students (who must move to other dormitories or off campus after the first year) provides a key research opportunity due to the constantly renewed experimental population [10]. An expansion of the use of Makahiki to other settings could provide new opportunities for research on attitudes regarding renewable energy and sustainable habits.

Since the first three-week Kukui Cup round in 2011, Makahiki has begun an expansion to other competitions at the collegiate level. The 2012 Kukui Cup was scheduled to run through the end of the 2012-2013 academic year [9]. In addition, the Makahiki framework was used for sustainability competitions at Hawaii Pacific University (HPU) and the East-West Center in 2012 [9]. Though future plans for expansion target schools at the elementary education level, these goals of reaching a wider audience will be difficult to realize until Makahiki becomes easier to use for people who are unfamiliar with the system but still want to create simple competitions [9]. This project will facilitate the expansion of Makahiki by attempting to create a design tool that will improve the way in which the user interacts with the user interface while setting up a competition.

1.3. Thesis

A redesigning of the Makahiki administrative user interface to address user-reported difficulties in configuring new sustainability challenge games will significantly affect the time required to configure challenges and the perceived ease of use of the administrative interface.

2. Methods

2.1. Approach: Action Reseach and Iterative Development

This research proposal bases its methods on action research, a software engineering methodology which follows an iterative cycle of development and testing. The action research cycle begins with the identification, through surveys or other qualitative methods, of the conditions under which the software system is being used. This information is used to attempt to change those circumstances. Further qualitative research is then used to identify the changed circumstances created by that action [11]. This iterative approach is compatible with a typical software engineering design cycle. Hevner et al. [12] and Kushniruk and Patel [3] describe a development process which begins with the evaluation of a product based on data gathered from case studies, experiments, or simulations. This usability feedback is used to develop and test a new version of the product. The new version is then tested, which produces further usability feedback which can be used to redesign other features of the system. This methodology, over many cycles of development, leads to further refinement of the software product and the methods used to determine its usability.

2.1.1. Testing Procedure.

I will be using a general procedure for usability testing based on the methods used by Kushniruk and Patel [3] and Fang and Holsapple [2], in which test subject groups which were using different user interfaces performed the same task in each and were surveyed to determine the time it had taken them to complete each task and to record their qualitative opinion of the interface's usability. Though it will not necessarily be possible to accomplish every task performed by test subjects from Round 1 during Round 2, Round 2 will use a subset of Round 1's tasks which are compatible with the design tool. After each test subject's session with Makahiki is complete, he or she will be asked to complete a survey.

Round 1 took place in Spring 2013, with the current, menu-based version of Makahiki which does not provide guidance to the user. This round was intended to collect feedback about Makahiki's usability problems from the perspective of users with no prior experience with the system, which will be used to identify areas of the configuration process which the design tool will attempt to streamline. Students in Professor Johnson's ICS 691 course completed a representative set of configuration tasks in Makahiki for a course assignment and completed a survey. Each survey question asks the test subject to record the time taken to complete each task and describe any problems they experienced while using Makahiki. This survey is reproduced below in Appendix A. In addition, students completed long-form blog entries which provided a more in-depth qualitative evaluation of their experiences with the system. The problems reported by users will be analyzed qualitatively to identify common usability issues, while completion time measurements will provide a quantitative measurement of the Makahiki systems usability. This process is represented in Figure 1, below.

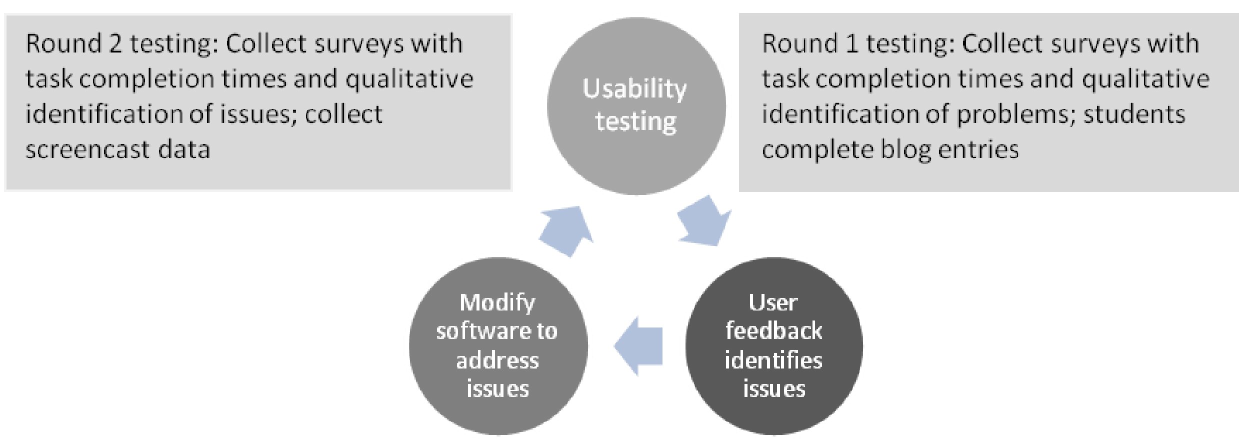

Figure 1. The action-research-based iterative testing and development process used in this proposal. In this proposal, only one full testing - development - testing cycle will be completed.

2.1.2. Hypotheses.

Though preliminary data is not yet available, three general hypotheses can be defined based on the quantitative measure of task completion time. Reduced completion times are considered improvements in usability. Hypotheses can be further defined based on whether the usability issues reported in standard Makahiki continue to be reported when the design tool is tested, even though my use of the action research methodology dictates that specific usability issues should not be predicted, but instead identified based on user feedback.

In the null hypothesis, the creation of a design tool is not followed by statistically significant changes in at least one configuration task time. In addition, under the null hypothesis, a qualitative analysis of usability issues discussed in the survey results would indicate that none of the issues extant in the previous version of Makahiki have been addressed by the redesign. This would indicate that the use of a design tool has no significant advantages over a menu system which provides no guidance to the user.

In one alternative hypothesis, the creation of a design tool is followed by statistically significant reductions in at least one configuration task time. In addition, under the alternative hypothesis, a qualitative analysis of usability issues discussed in the survey results would indicate that at least one of the issues extant in the previous version of Makahiki was not reported in the redesigned version. This would indicate that the use of a design tool had at least one significant advantage over a menu system which provides no guidance to the user.

In a second alternative hypothesis, the evaluation of the design tool produces data which indicates statistically significant increases in at least one configuration task time. In addition, qualitative analysis of usability issues discussed in the survey results would indicate that at least one new usability issue had been introduced by the redesign. This would indicate that the use of a design tool had at least one significant disadvantage relative to a menu system which provides no guidance to the user.

2.1.3. Limitations.

The first limitation of the usability testing procedures is a small sample size. The ICS 691 course which supplied the test subject students for Round 1 of usability testing had an enrollment of 10 students. Likewise, the procedure for Round 2 usability testing seeks to recruit 20 volunteers to carry out some or all of the same tasks as were completed by the Round 1 students. Though the small sample size increases the vulnerability of the data set to outliers, this usability procedure serves as the basis for future Makahiki usability testing with a wider audience.

Another limitation of these procedures is the comparability of the data sets which their surveys will produce. Though the survey distributed for Round 1 allows for task lengths of an hour or longer, reflecting the greater time available for users who are performing individual testing outside a classroom setting, Round 2 only allocates compensation for an hour per subject. It is probable that Round 2 of usability testing will only be able to test the design tools usability for a subset of the tasks used in Round 1.

Limited generalizability of results is also a potential problem for this study. Though the survey results and the survey design will be generally applicable to research in the field of user interface design, Makahiki's status as a software framework for creating sustainability games marks it as a product targeted at a highly specific market that, at least initially, will be small.

2.2. Budget and Timeline

2.2.1. Projected Budget.

Overall equipment costs for this experiment are low. The subjects in Round 1 of testing are providing their own computers. They will not be compensated because they are completing the survey and the Makahiki configuration as part of a course assignment. The twenty subjects in the second round of testing will be compensated at $20 per hour for an hour of testing, for a total cost of $400.00. Testing for the second round will take place on a single computer which will require a $299.00 Camtasia Studio software license. Camtasia will be used to record screencasts of subject activity during each users session of configuring Makahiki.

I am planning to attend the CHI 2014 conference in Toronto, Canada with my advisor to present the findings of this project. It is estimated that my registration fees for this conference will be $500.00, expenses will be $500.00, and round-trip airfare will be $1,000.00.

A total of $2699.00 in funding has been awarded from the Undergraduate Research Opportunities program at the University of Hawaii at Mānoa to cover these expenses. The breakdown of expenses described in this section is also described in Table 1, below.

2.2.2. Projected Timeline.

The timeline is described in Table 2, below. Based on data from Round 1, the design tool will be developed during the summer of 2013 and refined in September 2013 to produce the stable version which will be tested in Round 2. After the data from Round 2 is analyzed, several drafts of the final report will be prepared and submitted to my advisor in the Spring 2014 semester. Depending on dates yet to be determined for the SIGCHI conference, I will submit and present my paper at CHI 2014 and at the

Honors Spring Symposium in Spring 2014.

2.3. Predicted Results

Based on the usability problems reported in Round 1, I will develop an extension of Makahiki's administrative user interface that presents a simplified series of configuration steps to the user; this will be referred to as the "design tool." The design tool will be composed of multiple "sub-tools" which will be designed for specific sections. For example, if the design of badge triggers is found to be problematic due to badge requirement conflicts, the design tool might implement a sub-tool which would attempt to identify these conflicts and provide a warning to an administrator when a conflict was created. Due to the use of an action research-based methodology, specific usability issues will be identified from problems reported by test subjects and cannot be anticipated beforehand. Likewise, the design tool usability problems which test subjects will report in Round 2 cannot be predicted beforehand.

2.4. Conclusion

The goal of this research project is to conduct usability testing on the Makahiki serious games framework to identify common usability issues. These usability issues will influence the development of a design tool which will attempt to streamline the process of configuring Makahiki. The design tool will then undergo usability testing to determine whether or not it significantly reduced configuration times and whether or not subjects who tested the design tool reported the same problem as the subjects who tested the standard Makahiki version. This will determine whether or not the redesign adequately addressed usability problems identified in the standard Makahiki version. The results of this study will contribute to the understanding of the design process for serious game frameworks and to the development of the sustainability education efforts for which Makahiki is used.

References

[1] T. Hewett, R. Baecker, S. Card, T. Carey, J. Gasen, M. Mantei, G. Perlman, G. Strong, and W. Verplank, "Curricula for Human-Computer Interaction: Chapter 2: Human-Computer Interaction," in *ACM SIGCHI Curricula for Human-Computer Interaction*, 1996. [Online]. Available: http://old.sigchi.org/cdg/cdg2.html

A curriculum by the Association for Computing Machinery (ACM) which provides a rough outline of recommended lesson content for courses taught in human-computer interaction education. This chapter presents a working definition of human-computer interaction and of the process of analyzing user interfaces.

[2] X. Fang and C.W. Holsapple, "An empirical study of web site navigation structures impacts on web site usability," *Decision Support Systems*, vol. 43, no. 2, pp. 476—491, Mar. 2007.

The authors, researchers at Miami University and University of Kentucky, provide evidence in support of the use of a usage-oriented hierarchy or a combined hierarchy instead of a subject-oriented hierarchy in the design of a web sites navigation structure. Tasks of varying levels of difficulty were developed for use with a customized web site, in which test subjects were required to perform certain tasks within the user interface and their satisfaction, ease of use, correct answer ratio, and navigation time were assessed. In the first round of testing, usage-oriented hierarchy and combined hierarchy had statistically significant lower navigation times. In the second round, users reported statistically significant higher satisfaction and general ease of use for a usage-oriented hierarchy or combined hierarchy than for a subject-oriented hierarchy.

[3] A.W. Kushniruk and V.I. Patel, "Cognitive and usability engineering methods for the evaluation of clinical information systems," *Journal of Biomedical Informatics*, vol. 37, pp. 56—76, 2004.

The authors, researchers at York University (Toronto, Canada) and Columbia University (New York) respectively, conduct a literature review of research in the area of usability testing methods for medical information systems. It describes the use of surveys and video recording to collect information about a user's background and thought process. Likely due to technical limitations at the time, it recommends using an external video camera and a PC-to-video converter, instead of screen-recording software; however, the external video camera also serves to record anything the user might say, which captures his or her thought processes. It recommends the sorting of video data into coding categories for analysis, and the use of this data to improve the next iteration of the application design.

[4] F. Calisir and F. Calisir, "The relation of interface usability characteristics, perceived usefulness, and perceived ease of use to end-user satisfaction with enterprise resource planning (ERP) systems," *Computers in Human Behavior*, vol. 20, no. 4, pp. 505—515, 2004.

The authors, researchers at Istanbul Technical University in Turkey, used a survey to analyze user satisfaction with enterprise resource planning systems, which consist of “one database, one application, and a standard interface across the entire enterprise,” broadly similar to Makahiki’s dependence on a competition server accessed via a standard web interface. Perceived usability was found to be the most reliable predictor of satisfaction. It was dependent on how easily the interface could be learned, and how well the systems features met user requirements.

[5] D.C. McFarlane, “Comparison of Four Primary Methods for Coordinating the Interruption of People in Human-Computer Interaction,” *Human-Computer Interaction*, vol. 17, pp. 63—139, 2002.
The author, an engineer at Lockheed Martin’s Advanced Technology Laboratories, analyzes effects of four possible types of interruptions to the performance of tasks in user interfaces, finding that being interrupted produces more errors and that the literature at the time did not contain much information about solving interruption problems. Four types of interruption - immediate, negotiated, mediated, and scheduled - were tested by 36 volunteers (18 men, 18 women) for an abstract computer task. Task 1 required the user to track the positions of multiple objects on screen. Task 2, which interrupted Task 1, asked users to match shapes by shape or color. Immediate interruption randomly presented matching tasks without regard for the state of the game task; negotiated interruption notified the user and let them decide when to handle the task; mediated interruption presented matching tasks when the number of objects on screen was highest; and scheduled interruptions presented the matching game every 25 seconds. The author concluded that interruption causes statistically significant differences in user performance. This source was important to this paper primarily for its description of experiment design.

[6] J.P. Wanderer, A.V. Rao, S.H. Rothwell, and J.M. Ehrenfeld, “Comparing two anesthesia information management system user interfaces: a usability evaluation,” Canadian Journal of Anaesthesia, vol. 59, no. 11, pp. 1023—31, Nov. 2012
The authors, researchers at Vanderbilt University (Wanderer and Ehrenfield) and Massachusetts General Hospital (Rao and Rothwell), recorded user sessions and survey results for two anesthesia information management systems (AIMS) to test for the existence of significant differences in the usability of two AIMS user interfaces in a simulated clinical database populated by data from twenty anesthesia providers. Use of the user interface labeled as “revised” increased documentation accuracy and reduced the number of user interactions needed to complete tasks. Though the time required to document airway information was reduced, there was no significant difference in the total time required to complete intravenous documentation or to complete all tasks, and test subjects did not report a significant difference in the workload they perceived. Unlike Fang and Holsapple (2007), in which testing was conducted on a user interface constructed specifically for the study, this study by Wanderer et al. used real-world AIMS databases with simulated clinical data.

[7] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From Game Design to Gamefulness: Defining "Gamification"," in *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 2011, pp. 9—15.

The authors are from Hamburg University (Germany), University of the West of England (Bristol, United Kingdom), IT University of Copenhagen (Denmark), and the University of Ontario Institute of Technology (Oshawa, Canada). This literature review attempts to define the meaning of the term "gamification," which has seen increasing use to describe a software application which adopts elements of video games in the service of promoting a service, product, or type of social change. Differentiating between "serious games" and "gamified applications," the authors conclude that gamification refers to the "use [...] of design [...] elements [...] characteristic for games [...] in non-game contexts (15)" without regard to how the application was intended to be used, what its context is, or what medium it was designed for.

[8] P.M. Johnson, Y. Xu, R.S. Brewer, G.E. Lee, M. Katchuck, and C.A. Moore, "Beyond kWh: Myths and fixes for energy competition game design," in *Proceedings of the Meaningful Play 2012 Conference*, 2012, 10 pp., non-paginated [Online]. Available: http://meaningfulplay.msu.edu/proceedings2012/mp2012_submission_72.pdf

A conference paper which analyzes the results of the 2011 Kukui Cup and describes its game mechanics in detail. The authors found that many of the recorded changes in behavior during competition were unsustainable in the long term, and that data collection in this study and others failed to account for changes in energy use after the end of the competition, which the authors argue may actually be the period which is most important for identifying changes in behavior. In this paper, it was used as the basis for a description of Kukui Cup game mechanics.

[9] P.M. Johnson, Y. Xu, R.S. Brewer, C.A. Moore, G.E. Lee, and A. Connell, "Makahiki+WattDepot: An open source software stack for next generation energy research and education," in *Proceedings of the 2012 Conference on Information and Communication Technologies for Sustainability*, 2013, 8 pp., non-paginated [Online]. Available: https://csdl-techreports.googlecode.com/svn/trunk/techreports/2012/12-06/12-06.pdf

A conference paper by members of the Makahiki development team which describes the nature of the integration of WattDepot into Makahiki and proposes the use of the combined systems for purposes of energy research and education. It describes the capabilities of WattDepot for aggregating energy data and serving it to clients, and the capabilities of Makahiki to request data from WattDepot and integrate it into sustainability-related activities are described.

[10] R.S. Brewer, G.E. Lee, and P.M. Johnson, "The Kukui Cup: a Dorm Energy Competition Focused on Sustainable Behavior Change and Energy Literacy," in *Proceedings of the 44th Hawaii International Conference on System Sciences*, 2011, 10 pp, non-paginated. [Online]. Available: http://csdl.ics.hawaii.edu/techreports/10-07/10-07.pdf

A conference paper by Dr. Philip Johnson and two other researchers from the University of Hawaii, describing the capabilities of Makahiki and WattDepot prior to the first Kukui Cup in 2011. It frames the value of Makahiki in terms of raising students awareness of their energy consumption patterns by collecting and providing feedback and real-time statistics.

[11] Y. Dittrich, M. John, J. Singer, and B. Tessem, "Editorial: For the Special Issue on Qualitative Software Engineering Research," *Information and Software Technology*, vol. 49, no. 6, pp. 531—539, June 2007.
This editorial provides an overview of differing methods used to integrate qualitative methods into the normally quantitative discipline of software engineering. The authors argue that qualitative research methods can collect data on subjective parts of the user experience that quantitative research cannot measure. One of the methods discussed is "action research," which cycles between usability testing and the development of new software with the goal of producing iterative design improvements.

[12] A.R. Hevner, S.T. March, J. Park, and S. Ram, "Design Science In Information Systems Research, MIS Quarterly, vol. 28, no. 1, pp. 75—105, March 2004.
The authors, researchers at the University of South Florida, Vanderbilt University, Korea University, and University of Arizona, respectively, propose a paradigm for information systems research and design and examine elements of this paradigm which are present in three case studies. This study was important to this project primarily for its description of an iterative process for collecting feedback, improving a product based on that feedback, and then collecting feedback again.

Appendix

A. Appendix A: Survey Instrument for Round 1

The following set of questions was administered as a Google Forms document to ICS 691 Spring 2013 students from March 19 through March 24, 2013. Participation in the survey was required for the completion of the assignment. The assignment required users to configure a sustainability challenge in Makahiki consisting of several smaller configuration tasks, based on online documentation. References to Heroku are related to a cloud application platform on which students individual copies of Makahiki were deployed. The source code for the version of Makahiki made available to students at the time of this assignment will be available upon request through 2014. The survey is reproduced below.

A.1. Survey

Makahiki Configuration and Management Log
Please follow the steps outlined in this form to configure and manage Makahiki, and log the time you spent and problems encountered for each step. Record the time you actually spent doing the tasks by choosing the closest value from the list that best matches the time you spent.

The Makahiki manual referenced below may use the local instance 127.0.0.1 as the example. For this assignment, you should use the Makahiki instance you deployed in Heroku instead of your local instance.

Thank you !

* Required

0. Update your Heroku Makahiki instance *
Read the "Updating your Makahiki instance" section in Makahiki Manual (http://makahiki.readthedocs.org/en/latest/installation-makahiki-heroku.html#updating-your-makahiki-instance). Follow the instructions to update your Heroku instance with any changes from the Makahiki Git repository. Record the time you spent for this step only:

- 5 minutes
- 10 minutes
- 30 minutes
- 1+ hour

Record any problem(s) you encountered in this step:

1. Getting to the challenge design page *

Read the "Getting to the challenge design page" section in Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design.html#getting-to-the-challenge-design-page). Then go to the challenge design setting page of your Heroku instance. Record the time you spent for this step only:

- 1 minutes
- 5 minutes
- 15 minutes
- 1+ hours

Record any problem(s) you encountered in this step:

2. Design the global settings *

Read the "Design the teams" section in Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-teams-settings.html). In your Heroku instance, add a new team called "Lehua-C" with the same group membership as the other teams in the default instance. Record the time you spent for this step only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1+ hours

Record any problem you encountered in this step:

3. Design the teams *

Read the "Design the teams" section in Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-teams-settings.html). In your Heroku instance, add a new team called "Lehua-C" with the same group membership as the other teams in the default instance. Record the time you spent for this step only:

- 2 minutes
- 5 minutes
- 15 minutes
- 30 minutes
- 1+ hours

Record any problem you encountered in this step:

4. Set up users *

Read the "Set up users" section in Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-players-settings.html). Add two new users of your choosing to the team "Lehua-C". Make sure you assign the players to their team by going to the user's profile link. Test your changes by logging in as one of the new players, and verifying that the player is on the right team. Record the time you spent for this step only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

5. Specify the games to appear in your challenge *

Read the "Specify the games to appear in your challenge" section in Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-game-admin-enable-disable.html). Disable the "Water Game", and leave the other games enabled. You should see that the "Drop Down" page disappears from the top navigation bar. Record the time you spent for this step only:

- 2 minutes
- 5 minutes
- 15 minutes
- 30 minutes
- 1+ hours

Record any problem you encountered in this step:

6. Learn about how to design the resource goal games *

Read the “Design the Resource Goal Games” section in the Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-game-admin-resource-game.html). Record any questions or confusion that arises from reading this section:

6.1. Configure the Energy Goal Game for your new team *

Change the energy goal setting for the team “Lehua-C” to use manual data, and specify a time for the manual data input time. Test your changes by logging in as a player of Lehua-C, then go to ”Go Low” page. You should see the calendar view of the daily energy goal game instead of the stop light visualization. Record the time you spent for this step only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

7. Learn about how to design Smart Grid Games *

Read the “Design the Smart Grid Game” section in the Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-game-admin-smartgrid-game.html). Record any questions or confusion that arises from reading this section:

7.0 Design on paper

The default installation defines a Smart Grid Game (SGG) with 3 levels. For this task, design a new Level 4 that extends the existing SGG. Level 4 will have a total of four actions: 3 new actions (Activity, Event, Commitment) that you create yourself, and one old action that you choose from the existing library of actions in the default installation. Design Level 4 with a 2x2 grid layout, including 2 categories of your choice. For this step, you will only design your Level 4 on a piece of paper or a spreadsheet, as described in Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-game-admin-smartgrid-game.html#designing-your-smart-grid-game). Specify the unlock conditions for each action to achieve some kind of unlocking sequence(“path”), such as depending on the completion of other actions.

Record the time you spent in this step:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

7.1 Create a Level *

Add a new level “Level 4”, with priority higher than Level 3, and some unlock condition depending on some actions from Level 2. Record the time you spent for this step only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

7.2 Create a new Activity action *

Create a new activity action with your own content. Make the content meaningful. Fill in the required fields. You will also specify the level (should be level 4), category (your choice), as well as the unlock condition field, which determines the action ”path” of your SGG design as described in step 7.0. Record the time you spent for this step only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

7.3 Create a new Event action *

Create a new event action with your own content. Make the content meaningful. Fill in the required fields. You will also specify the level field (should be level 4), category field (your choice), as well as the unlock condition field, which determines the action "path" of your SGG design as described in step 7.0. Record the time you spent for this step only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

7.4 Create a new Commitment action *

Create a commitment action with your own content. Make the content meaningful. Fill in only the required fields. You will also specify the level field (should be level 4), category field (your choice), as well as the unlock condition field, which determines the action "path" of your SGG design as described in step 7.0. Record the time you spent for this step only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

7.5 Finalize the grid *

At this point, you should have created 3 new actions and put them in Level 4 of your SGG. For this step, find the final action to complete your 2x2 grid. Go to the admin interface, find an action in the action library, and modify the level, category and unlock condition field according to your SGG design. Play-test your grid by logging in as normal player, go to the "Get Nutz" page, unlock Level 4 and all actions in Level 4. Record the time you spent for this step only:

- 5 minutes
- 15 minutes

- 30 minutes
- 1 hour
- 2 hours
- 3+ hours

Record any problems you encountered in this step:

8. Design the Top Score Game *

Read the “Design the Top Score Game” section in the Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-game-admin-topscore-game.html), create a new topscore prize of your choice. Test your changes by going to the “Prizes” page to see your newly created prize. Record the time you spent for this section only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

9. Design the Raffle Game *

Read the “Design the Raffle Game” section in the Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-game-admin-raffle-game.html). Create a new raffle prize of your choice. Test your changes by going to the “Prizes” page to see your newly created raffle prize and you can add raffle ticket to it. Record the time you spent for this section only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

10. Design the Badge Game Mechanics *

Read the “Design the Badge Game Mechanics” section in the Makahiki Manual (http://makahiki.readthedocs.org/en/latest/challenge-design-game-admin-badge.html). Create a new badge with an award trigger type of “smartgrid”. Specify some kind of awarding condition depending on the smartgrid operations. Verify that your badge shows up in the badge catalog page and you can be awarded the new badge by doing the specified smartgrid action. Record the time you spent for this section only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record any problem you encountered in this step:

11. Manage Action Submissions *

Read the “Manage Action submissions” section in the Makahiki Manual (http://makahiki.readthedocs.org/en/latest/execution-manage-smartgrid-game.html#manage-action-submissions). Approve some actions submitted by you during your playtesting. Record the time you spent for this section only:

- 5 minutes
- 15 minutes
- 30 minutes
- 1 hour
- 2+ hours

Record how many actions you approved, and record any problem you encountered in this step:

Your UH email: *

Table 1. Itemized Budget

Item	Quantity	Cost	Justification
Item	**Quantity**	**Cost**	**Justification**
Camtasia Studio software license	1	1 * $299.00 = $299.00	Screen recorder to capture test subject activity during usability testing.
Test subject compensation	20	20 * $20 = $400.00	20 test subjects at $20 per hour for 1 hour.
CHI 2014: Registration fee	1	1 * $500 = $500.00	Student registration fee for CHI 2014 conference.
CHI 2014: Airfare	1	1 * $1000 = $1000.00	Round-trip ticket from Honolulu to Toronto.
CHI 2013: Expenses	1	1 * $500 = $500.00	Hotel and food expenses for 3 to 4 days.
Total:	**$2699.00**		

Table 2. Timeline

Tasks	**Time Estimate**
Data collection for Round 1	March 19 to March 24, 2013
Round 1 data analysis: determine necessary components of design tool	May 2013
Development of design tool	May to August 2013
Beta version of design tool (mostly stable)	September 2 to 20, 2013
Final stable version of design tool	September 23 to October 4, 2013
Preparation of data collection equipment and facilities	October 7 to 18, 2013
Data collection for Round 2	October 21 to November 8, 2013
Analysis of screen recordings and survey data	November 15 to December 6, 2013
Draft manuscript sent to advisor	December 2013 to January 2014
Manuscript revision	January 2014
Submit manuscript to SIGCHI (data not yet determined); finalize Honors Manuscript	January to April 2014
Presentation at CHI 2014 conference	April 26 to May 2, 2014
Presentation at Spring Symposium	May 3, 2014