MAKAHIKI: A "SERIOUS GAME" ENGINE FOR SUSTAINABILITY

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Abstract

Sustainability education and conservation has become an international imperative due to the rising cost of energy, increasing scarcity of natural resource and irresponsible environmental practices. Over the past decade, running energy and water challenges is a focal point for sustainability efforts at university and industry campuses. Designers of those challenges have had three choices for information technology: (a) build their own custom in-house solution; (b) out-source to a commercial provider; or (c) use a minimal tech solution such as a web page and manual posting of data and results.

My research seeks to investigate the development and evaluation of information technology infrastructure that can effectively and efficiently support the development of serious games for sustainability. We developed a serious game engine for sustainability called Makahiki, which provides an open source, customizable, extensible IT infrastructure for creating serious games for the purpose of education and behavioral change regarding energy, water, food, and waste generation and use. Three organizations, namely, University of Hawaii at Manoa, Hawaii Pacific University and East West Center of Hawaii had successfully used the Makahiki to create their own sustainability challenges in 2012.

In order to evaluate the effectiveness and efficiency of an IT infrastructure for serious games for sustainability, I proposed an evaluation framework that address the perspectives from different stakeholders, namely players, game designers, game managers, system admins, developers and researchers. I will apply the proposed evaluation framework to Makahiki, as well as another IT infrastructure, Lucid Dashboard. This proposal describes the experimental design of such evaluations.

The anticipated contributions of my research includes: Makahiki as an example IT infrastructure for serious games for sustainability, an evaluation framework, evidences of the effectiveness and efficiency of Makahiki and Lucid Dashboard, and the insight into the strenghths and weakness of the evaulation framework.

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Chapter 1

Introduction

1.1 Sustainability Education and Behavior Change

The rising cost, increasing scarcity, and environmental impact of fossil fuels as an energy source makes a transition to cleaner, renewable energy sources an international imperative. One barrier to this transition is the relatively inexpensive cost of current energy, which makes financial incentives less effective. Another barrier is the success that electrical utilities have had in making energy ubiquitous, reliable, and easy to access, thus enabling widespread ignorance in the general population about basic energy principles and trade-offs. In Hawaii, the need for transition is especially acute, as the state leads the US both in the price of energy (over $0.30/kWh) and reliance on fossil fuels as an energy source (over 90% from oil and coal).

Moving away from petroleum is a technological, political, and social paradigm shift, requiring citizens to think differently about energy policies, methods of generation, and their own consumption than they have in the past. Unfortunately, unlike other civic and community issues, energy has been almost completely absent from the educational system. To give a sense for this invisibility, public schools in the United States generally teach about the structure and importance of our political system (via classes like "social studies"), nutrition and health (through "health"), and even sports (through "physical education"). But there is no tradition of teaching "energy" as a core subject area for an educated citizenry, even though energy appears to be one of the most important emergent issues of the 21st century.

On the other hand, changing people's behavior with respect to energy holds significant promise in reducing energy use. Darby's survey of energy consumption research found that identical homes could differ in energy use by a factor of two or more [5]. Data from a military housing community on Oahu show energy usage for similar homes can differ by a factor of 4 [14].

1.2 Collegiate dormitory sustainability competition

Over the past decade, running energy and water challenges have become a focal point for sustain- ability efforts at university and industry campuses, to facilitate and incentivize energy and water reduction. Designers of those competitions have had three choices for information technology: (a) build their own custom in-house solution; (b) out-source to a commercial provider; or (c) use a minimal tech solution such as a web page and manual posting of data and results.

Petersen et al. describe their experiences deploying a real-time feedback system in an Oberlin College dorm energy competition in 2005 that includes 22 dormitories over a 2-week period [15]. Web pages were used to provide feedback to students. They found a 32% reduction in electricity use across all dormitories. However, in a post-competition survey, respondents indicated that some behaviors, such as turning off hallway lights at night and unplugging vending machines were not sustainable outside the competition period. Overall, there has been little analysis on energy usage after competitions finish, or how positive behavior changes could be sustained.

The Building Dashboard [12], developed by Lucid Design Group, is used to support Oberlin's dorm energy competition, as well as the Campus Conservation Nationals, a nationwide electricity and water use reduction competition on college campuses [**?**]. The Building Dashboard enables viewing, comparing and sharing building energy and water use information on the web in compelling visual interface, but the cost of the system creates the barrier for wider adoptions. In addition, the building dashboard solutions focus on providing energy information as a passive media. There is little interaction between participants and the system.

1.3 Serious games and Gamification

Another emergent issue is the explosive spread of game techniques, not only in its traditional form of entertainment, but across the entire cultural spectrum. Games have been shown with great potential as successful interactive media that provide engaging interfaces in various serious contexts [**?**, **?**]. Priebatsch attempts to build a game layer on top of the world with his location-based service startup [**?**]. The adoption of game techniques to non-traditional areas such as finance, sales, and education has become such a phenomenon that the Gartner Group included "gamification" [6] on its 2011 Hype List.

Reeves et al. described the design of Power House, an energy game that connects home smart meters to an online multiple player game with the goal to improve home energy behavior [16].

In the game, the real world energy data are transformed into a "more palatable and relevant form of feedback", and players may be incentivized by the in-game rewards to complete more energy-friendly real-world behaviors.

ROI Research and Recyclebank launched the Green Your Home Challenge as a case study of employing gamification techniques online to encourage residential green behavioral changes offline [**?**]. Working with Google Analytics, the results show a 71% increase in unique visitors and 97% of participants surveyed said that the challenge increased their knowledge about how to help the environment.

1.4 Research Description

The overall research question that will be investigated is: What forms of information technology infrastructure can support effective and efficient development of serious games for sustainability?

In order to address this research question, I started with two development tasks:

- Develop example IT infrastructure for development of serious games for sustainability.
- Develop an evaluation framework for IT infrastructure that provides evidence of the effectiveness and efficiency for the development of serious games for sustainability.

1.4.1 Makahiki

We developed a innovated serious game framework for sustainability called Makahiki, as an example IT infrastructure for the development of sustainability challenges. Makahiki explores one section of the design space where virtual world game mechanics are employed to affect real world sustainability behaviors. The ultimate goal of the Makahiki project is to learn to not just affect behaviors during the course of the game, but to produce long lasting, sustained change in behaviors and outlooks by participants.

Makahiki has a unique feature set intended to foster more rapid innovation and development. These features include: (1) an open source li- cense and development model which makes the technology available without charge and facilitates collaborative development and improvement; (2) support for an ecosystem of extensible, interre- lated, customizable games and activities; (3) real-time game analytics for research and evaluation; (4) pedagogically organized and extensible

learning activities; (5) a responsive user interface supporting mobile, tablet, and laptop displays; and (6) support for deployment to the cloud as an inexpensive option for hosting the competition.

The Makahiki framework had been successfully used in 2012 by three organizations, namely, University of Hawaii at Manoa, Hawaii Pacific University, EastWest Center of University of Hawaii, to implement individually tailored sustainability challenges focusing on energy and water conservation.

1.4.2 Evaluation Framework

In order to evaluate the effectiveness and efficiency of IT infrastructure for serious games for sustainability, I proposed an evaluation framework that address the perspectives from different stakeholders, namely players, game designers, game managers, system admins, developers and researchers. A set of evaluation mechanism is described in this proposal to determine the extent to which the system is effective and efficient with respect to these roles.

1.4.3 Evaluation

I will apply the proposed evaluation framework to Makahiki, as well as another IT infrastructure, Lucid Dashboard, to gather evidences of the effectiveness and efficiency of Makahiki and Lucid Dashboard, and to gain insight into the strenghths and weakness of the evaulation framework.

1.5 Outline

The proposal is organized into the following chapters:

- Chapter 2 looks at related research, including dorm energy competitions, serious game, gamification.
- Chapter 3 describes the design and implemention of the Makahiki system.
- Chapter 4 describes the evaluation framework for the serious games IT infrastructure for sustainability.
- Chapter 5 lists our research questions and explains our plan to evaluate them.
- Chapter 6 concludes the proposal with a list of anticipated contributions and future directions.
- Chapter 7 contains questionnaire to be administered to various roles in the evaluation.

Chapter 2

Related Work

This chapter examines related research in this area. The related work on sustainability education and conservation is discussed in Section 2.1. Section 2.2 investigates the recent development of "gamification". Section 2.3 looks at the applications of "serious game" and other related concepts that motivate and influence behavior changes. Finally, Section 2.4 examines the game related metrics and analytics of game systems.

2.1 Sustainability Education and Conservation

This section discusses the related work in the area of sustainability education and conservation applications.

2.1.1 Energy Competition

Energy competitions or challenges have been introduced to college dormitories and residential homes as ways to facilitate and incentivize energy reduction. Petersen et al. describe their experiences deploying a real-time feedback system in an Oberlin College dorm energy competition in 2005 that includes 22 dormitories over a 2-week period [15]. Web pages were used to provide feedback to students. They found a 32% reduction in electricity use across all dormitories. However, in a post-competition survey, respondents indicated that some behaviors, such as turning off hallway lights at night and unplugging vending machines were not sustainable outside the competition period. Overall, there has been little analysis on energy usage after competitions finish, or how positive behavior changes could be sustained.

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Figure 2.1. Building Dashboard (source: Lucid [12])

2.1.2 Power House - A Energy Game

Reeves et al. described the design of Power House, an energy game that connects home smart meters to an online multiple player game with the goal to improve home energy behavior [16]. In the game, the real world energy data are transformed into a "more palatable and relevant form of feedback", and players may be incentivized by the in-game rewards to complete more energy-friendly real-world behaviors.

2.1.3 RecycleBank - Making the World Sustainable

RecycleBank [**?**] introduced a series of "Green Challenges" that used gaming techniques online to motivate participants to learn about green living and to take small green actions to live more sustainable lives offline. According to their report [**?**], 49,000 individuals participated in the "Green Your Home Challenges". Partnered with Google Analytics and ROI research, they found that:

- Gamification can increase awareness of positive environmental actions. 97% of participants surveyed said the game increase their knowledge of environment.

Figure 2.2. Power House (source: Reeves [16])

- Games can drive individuals to take positive social and environmental actions. Most participants surveyed indicated they are very or extremely likely to take green actions as a result of participating in the challenge.
- Games are an effective and appealing educational tool. 86% participants agreed online games and contest can be a good way to inform and educate them personally.

2.2 Gamification

2.2.1 Defining Gamification

Although gamification is a popular word nowadays, there are quite a few definitions came from different fields. Bunchball, a company that provides gamification services to marketers defines gamification as "integrating game dynamics into your site, service, community, content or campaign in order to drive participation" [**?**]. Wikipedia defines gamification as "the use of game play thinking and mechanics to solve problems and engage audiences" [**?**]. They all seem to involve gamification with the goal of engagement. Some others consider any game related application is gamification, such as serious game, playful interaction and game-based technologies. Researcher Sebastian Deterding proposes an academic definition: "Gamification is the use of game design elements in non-game contexts" [6]. This is the definition we choose to use in our discussion.

(a) Green Your Home Challenge

What green actions do you take?	Pre	Post	% +
I turn off the lights	18%	26%	44%
I use CFL/Eco bulbs	28%	38%	36%
I conserve water/energy	34%	45%	32%
I buy local produce	0%	14%	----
I wash clothes in cold water	0%	7%	----

(b) Game Change Behavior

Figure 2.3. RecycleBank - Gaming for Good

2.2.2 Gamification Examples

There are many examples of applications that effectively employ game design elements. We will only briefly examine a few here for the purpose of better understanding the gamification concept and how it is utilized across a wide range of everyday life. The following examples are selected with the hope to cover the broad range of influential gamification cases. The list here is in no way the completed list. In this quickly evolving landscape, there may well be a risk of missing some eminent ones.

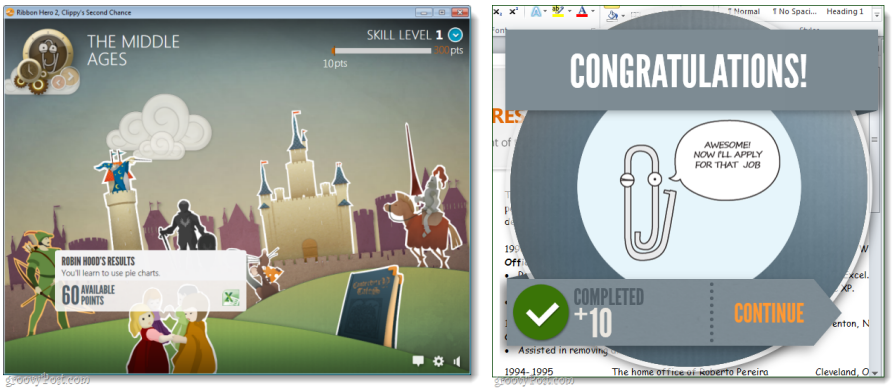
FourSquare [**?**] is a location-based game-like service where players check-in to locations for virtual points and rewards. It is probably the most recognized forerunner of applying game mechanics to location-based networking application. By employing gamification elements such as points, badges, levels and leader boards, it engages users to revisit a location such as restaurant or pub and become a loyal customer and finally the "mayor" of the place. Some virtual rewards such as the "mayors" of Starbucks or certain badges could be converted into real products, e.g. a free coffee. Foursqure proved that simple game mechanics can affect user behavior by engaging 10 million customers with a successful business model.

Figure 2.4. Foursquare makes modern badges popular

Nike+ [**?**] is a social running game-like application that employs game mechanics to encourage runners - both casual and hardcore - to compete and improve their fitness, with the goal to solve the main problem of most fitness programs: motivation. Nike+ makes it easy for runners to upload their exercise data to its web site, and start challenging themselves and their friends. They can also get supports from their friends through the web site. The game makes running and exercise fun.

Figure 2.5. Nike+ makes fitness run

RibbonHero [**?**] is a game that helps users discover new Microsoft Office features in a fun and motivating way. The goal is to have users build familiarity and expose them to the Office UI, so that they understand what kind of features are available. According to the creator of the game, Office "has a lot of powerful features that users might not know but can be really useful". The game gives users a chance to learn those features in a fun and engaging way, rather than reading the software manuals or watching the typically dry IT training videos.



(a) Quest to earn points (b) Competing a task

Figure 2.6. RibbonHero Helps to Learn Office

2.2.3 Why Games and Now

Gamification is not games. In fact, the subjects of gamification deal with everything else but games. However, to understand the research in gamification, we have to look at the studies of games. The games already prove to be an effective engaging media and ubiquitous as every day life. "Video game is everywhere" is the critical thesis of many gamification advocates.

Why game? Results of a study published in the May 1998 issue of Nature [**?**] demonstrated that video game players experienced regular releases of dopamine during game play. Dopamine is a neurotransmitter that signals pleasure rewards for food, sex and addictive drugs, such as cocaine. This and subsequent studies have proven that playing games stimulates pleasure centers in the brain. People are hard-wired to enjoy games.

Carnegie Mellon University professor and game designer Jesse Schell, who ignited the first wave of interest in gamification with a keynote address at the 2010 Design Innovate Communicate Entertain (D.I.C.E.) Summit, mentioned that he was surprised so many people took interest in his presentation now. He had talked about the phenomenon for years with little response. Back

in 2008, Gabe Zichermann coined the term ”funware”, which is the use of game mechanics to encourage desired user actions and generate customer loyalty [**?**]. Although it has the similar concept as gamification, the term “funware” did not gain enough traction then.

Why Now? According to Schell, “We’re moving from a time when life was all about survival to a time when it was about efficiency into a new era where design is largely about what’s pleasurable”. Online games have entered the mainstream and become the new revolution of culture shift, helped by platforms such as smart phones, tablets and Facebook. Gamification is a way to arrive at a “fundamental understanding of what it is that’s pleasurable to people” from many aspects of life.

Stanford professor Byron Reeves describes that a “Game Tsunami” is happening now in his book “Total Engagement” [**?**]. According to him, “Games Are Big” in three ways:

1. Big Bucks. Game industry is already a $10 billion market, one of the largest existing entertainment categories. Besides the traditional console and software sales, the current model of subscription fees, virtual goods sales and in-game purchase also account for the huge revenue for the game industry.

2. Big People. The stereotype about the majority gamers are unemployed youth is easily proved wrong. One research reveals that across all computer games, the average age of gamers is 35, and 26% of players are over 50, an increase from 9% in 1999. Another research shows the mean household income of players in one popular MMO (Multi-Player Online game) was about $85,000, and almost two-thirds of the players have some college education.

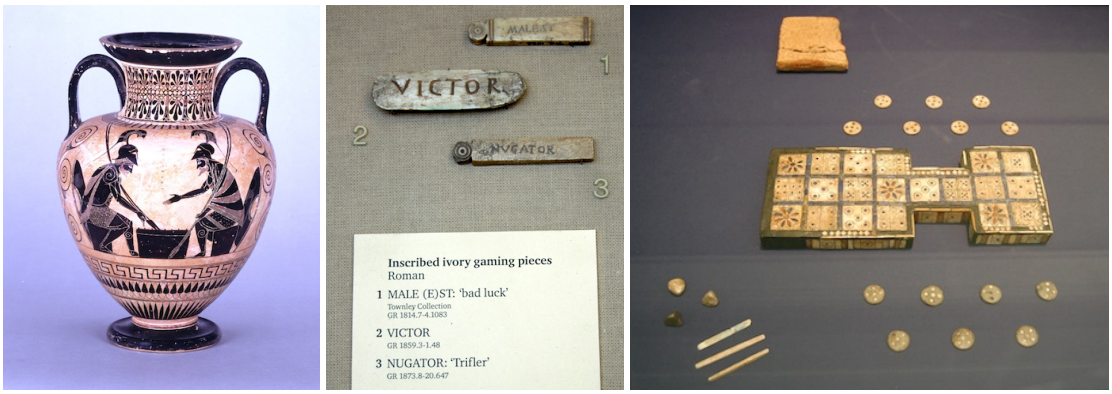
3. Big Time. “One sizable cohort of players who are thirty-something, most with a full-time job and many with a family, play MMOs over 25 hours per week, compared with 7 hours a week for all video games”.

In the British Museum’s department of Greek and Roman antiquities, there is an exhibition section about ancient games. The description of the exhibition states that “We know very little about how most ancient games were played. Their rules were probably too familiar for people to take the trouble of writing them down”. A favorite subject of Greek vase-painters was Ajax and Achilles playing a kind of board game called backgammon as illustrated in Figure 2.7. It is noteworthy that both Ajax and Achilles have the full armor on while playing the game. According to Arthur A. Krentz, Plato’s “Republic” described the connection between play and education of both adult and children. He points out that, the term “paideia” (in Greek, means education/culture), “paidia” (means play/game/pastime/sport), and “paides” (means children), have the same root. The three terms often show up in the same context. “The central aim of pedagogy (paidagogia) is to

encourage learning as a form of play (paidia), which is the most persuasive and effective approach to learning" [**?**].

Another game artifact exhibited in the museum is a set of label-shaped ivories, inscribed on one side with words and on the other with numbers. The series of numbers run from 1 to 25. The higher numbers have inscriptions of complimentary words, such as FELIX ("lucky") and BENIGNE ("kindly") [**?**]. The pieces may have been used in the Roman game called "the game of soldiers". One can relate the inscribed ivory pieces to the badges in modern games.

Yet another important game antique in the museum is the Royal Game of Ur, dated from the First Dynasty of Ur, before 2600BC. It is one of the most popular games of the ancient world, and probably the oldest set of board game equipment ever found. The beauty of the equipment is still amazed by the audience today. Wikipedia notes that the game of Ur is still played in current day Iraq. [**?**].



(a) Ajax and Achilles Playing (b) Ancient Game Badges (c) The Royal Game of Ur

Figure 2.7. The Beauty of Ancient Board Games in British Museum

In modern day, World of Warcraft (WoW) is a massively multiplayer online role-playing game (MMORPG) with 11.1 million subscribers, currently the world's most popular MMORPG. More than 50 billion hours have been spent in playing the game since the start of this game in 2004. The players created 250,000 articles in the WoW-Wiki, the second largest wiki behind Wikipedia. On average each WoW-player spends from 17 to 21 hours per week playing WoW.

Nick Yee describes 5 motivation factors why people play MMORPGs [**?**]: (1) Relationship: Players desire to develop meaningful relationships with other players in the game as supportive friendship. (2) Immersion: Players enjoy being immersed in a make-believe construct such as a fantasy world. (3) Grief: Player desire to objectify and use other players for one's own gains by killing

or deceiving. (4) Achievement: Players desire to become powerful by reaching the goals defined by the game. (5) Leadership: Players desire the gregariousness and assertiveness in a group.

Yee also noted that the shared experience, the collaborative nature of most activities makes MMORPG unique. "It?s the people that are addictive, not the game". "Most importantly, it is the reward of being socialized into a community of gamers and acquiring a reputation within it" [**?**]. He claimed that "WoW truly is a virtual Skinner box", smoothly increasing reward and difficulty and reinforcing player commitment along the way [**?**].

In her popular and inspiring TED talk "Gaming can make a better world" [**?**] and in her book "Reality is Broken" [**?**], researcher and game designer Jane McGonigal illustrated why good games make us better, and how they can help us change the world. She notes that currently more than 3 billion hours a week is spent in playing video game by our society, for good reasons. She says that the average gamer plays 10,000 hours of games by age 21. That?s about the same number of hours that students spent in high school and middle school. There are 500 million gamers today, playing on all sorts of platforms from the iPhone to the game consoles. Instead of the common conception that gaming is a waste of time, she argues that "playing games is the single most productive thing we can do with our time" and is the solution to the "Broken Reality". According to McGonigal, games are "unnecessary obstacles" that we volunteer to tackle. "eustress" or positive stress is the reason we spend so much time on unnecessary obstacles. Based on the findings of positive psychology, She argues that the blissful productivity comes from positive emotion, relationships, meaning and accomplishments while playing games.

Another instrumental work came from Byron Reeves's book "Total Engagement" [**?**]. He argues that games, especially MMO type games, can change the ways people work and businesses compete. He illustrates ten ingredients of great games and how to use them to design a better productive work place: (1) Self-representation with avatars. (2) Three-dimensional virtual environments. (3) Narrative context. (4) Feedback. (5) Reputations, ranks, and levels. (6) Marketplaces and economies. (7) Rules that are explicit and enforced. (8) Teams. (9) Communication system that can be reconfigured by participants. (10)Time pressure.

In his book "Game Based Marketing" [**?**], Gabe Zichermann stated that "FunWare" is about taking the lessons learned from the game industry and bake them into any kind of life experience. Marketing has always been about a certain degree of persuasion and motivation, and a degree of manipulation. Games do that most effectively. "Game mechanics and the psychological conditions are powerful tools that marketers can use, and they are a lot cheaper ... than cash in the long

run". "Games are the only force in the known universe that can get people to take actions against their self-interest, in a predictable way, without using force".

2.2.4 Science behind Gamification: Motivation and Behavior Change

Researchers from game industries and academia, have studied the psychology of motivation that makes games so engaging.

Psychology professor Mihaly Czikszentmihalyi introduced a specific kind of happiness that he named "flow" [4], which is considered as one of the fundamental reasons that people play games [**?**]. Flow is a state of absorption, characterized by intense concentration, loss of self-awareness, a feeling of being perfectly challenged (neither bored nor overwhelmed) and a sense that time is flying.

In order to achieve the flow, the important condition is a balanced goal that is challenging yet achievable within the individual's ability. A task that is not challenging or requires excessive time to complete becomes boring and players lose interest; A task that is too hard causes frustration and anxiety and again players lose interest. With a person's skills improve over time, the challenge needs to increase along with the improving skills. This balance is referred to as the flow channel as shown in figure 2.7.

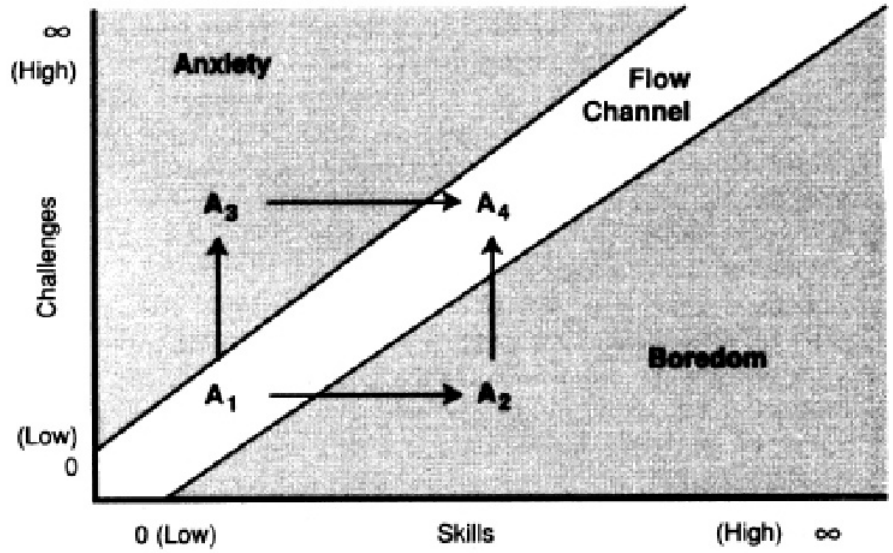


Figure 2.8. The state of flow is achieved between anxiety and boredom (source: Czikszentmihalyi [4])

In order to understand why people play games, Richard Bartle identified four player personality types by studying players of the Multi-User Dungeon (MUD) game in 1960s [**?**]. The four types are based on the 2 underlying axes:

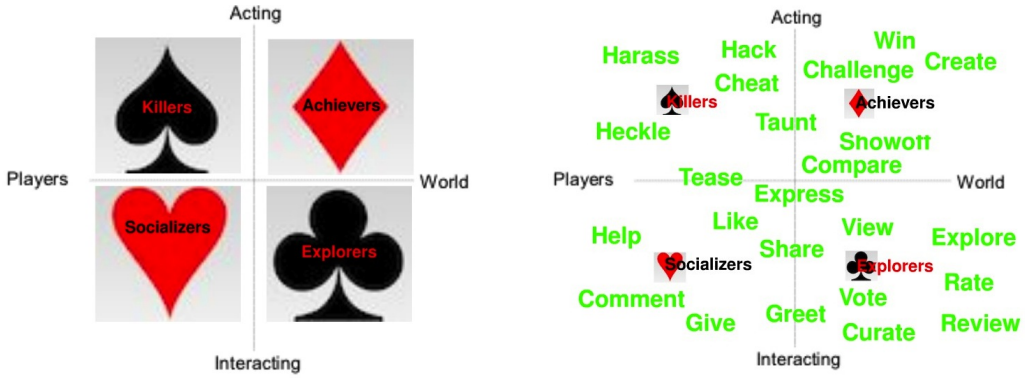
1. Achievers: driven by in-game goals, usually some form of points gathering - whether experience points, levels, or money.

2. Explorers: driven to find out as much as they can about the virtual construct - including mapping its geography and understanding the game mechanics.

3. Socializers: use the virtual construct to converse and role-play with their fellow gamers.

4. Killers: use the virtual construct to cause distress on other players, and gain satisfaction from inflicting anxiety and pain on others.

Bartle's player type model has been the basic for understanding the player motivation. Dan Dixon presented the limitation and misuse of Bartle's model in general games and gamification contexts [**?**]. Amy Jo Kim applied the model in her gamification approach by overlaying social actions from the game on top of the player types [10], as shown in Figure 2.8.



(a) Bartle's Player Types (1996)

(b) Kim's Social Actions (2010)

Figure 2.9. Player Types

Stanford University researcher BJ Fogg introduces the Fogg Behavior Model (FBM) to explain what causes behavior change [**?**]. The model shows that three elements must converge at the same moment for a behavior to occur: (1). Motivation: the person wants desperately to perform the behavior. (2). Ability: the person can easily carry out the behavior (3). Trigger: the person is triggered to do the behavior. The model is illustrated in Figure 2.7.

Michael Wu uses FBM to analyze why and how gamification is able to drive actions [17]. "Game mechanics and game dynamics are able to positively influence human behavior because they

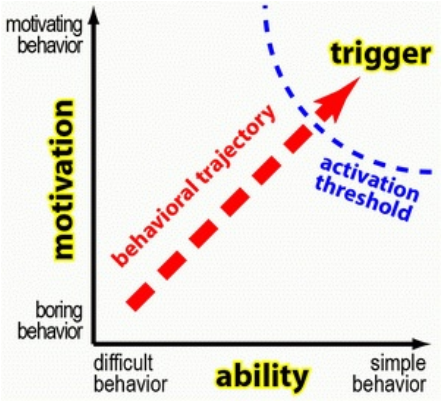


Figure 2.10. Fogg Behavior Model (source: Lithium [17])

are designed to drive the players above the activation threshold, and then trigger them into specific actions". Wu suggests that gamification is an iterative process and works best when all three of motivation, ability, and trigger converge.

Another Stanford Researcher Kaptein developed a technique he called "Persuasion Profiling" to build a profile of which psychological triggers work best for a given person, and uses these triggers to drive new behaviors in the future [**?**].

2.2.5 Gamification Debates and Criticism

There are many debates and criticism over whether gamification itself is inherently good or bad.

In a debate-style session of GDC 2011, "The Great Gamification Debate", panelists, divided by two sides, argued the merits of bringing gameplay mechanics to just about everything [**?**]. Although they mostly agreed that definition of gamification was summed up best by Jesse Schell, "gamification is taking things that aren't games and trying to make them feel more like games", there are a lot different opinions between the two sides. While the pro-gamification side believed the gamification is the cultural shift in every day life, the other side considered that the purpose of gamification is to cash in on the current popularity of games. While the anti-gamification side reduced the idea to merely behavioral conditioning or a kind of Skinner box for users, the pro side maintained that users should at least find a reward of values.

Designer Umair Haque argued that most gamification is about zero sum games, or artificial scarcity [**?**]. For example, many "gamified" sites simply offer a fixed number of badges, or other trinkets. For someone to win, someone else got to lose. Designer Stephen Anderson also

claimed that [1]: (a) gamification mistakes extrinsic rewards (rather than intrinsic motivation) for the power of games and hence offers only feedback, not goals & rules. (b) a long-term successful product or service that?s not pure entertainment must go beyond delight/entertainment and be first & foremost useful. His idea is illustrated in Figure 2.8.

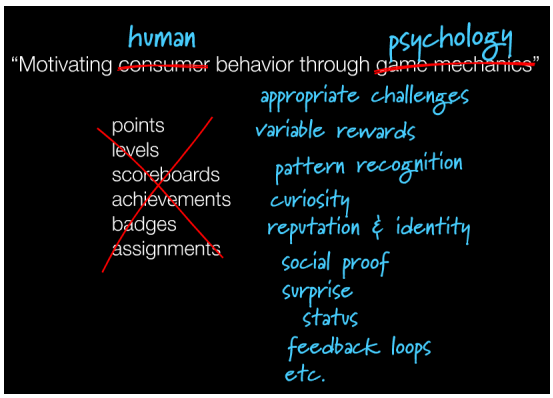


Figure 2.11. Gamification is about extrinsic rewards (source: Anderson [1])

Although Jane McGonigal is the advocate of employing games in reality, she spoke about her concern about current state of gamification in the GDC 2011 talk titled "We don?t need no stinking badges: How to reinvent reality without gamification" [**?**]. She argued that current gamification confuses intrinsic/extrinsic motivation and proposed "Gameful Design" instead of "Gamification". She claimed that "Gameful is player-oriented", which presumed that the loyalty program type gamification is product or service oriented. While the current gamification is about extrinsic reward, with points, badges, and levels, gameful design is about intrinsic reward, with positive emotion, relationships, meaning and accomplishment.

The followings are a few eminent criticisms of gamification:

Georgia Institute of Technology professor and game designer Ian Bogost called gamification efforts "exploitation-ware" that is being "invented by consultants" and claimed that "gamification is bullshit" [**?**]. Gamification, he argued, "gets games wrong, mistaking incidental properties like points and levels for primary features like interactions with behavioral complexity". In the GDC 2011 gamification debate, he contrasted that "To take something like games, which are complicated, and substitute it out for points and badges is a very efficient way to get a hot culture commodity into your product" [**?**].

In her blog, game designer Margaret Robertson stated that current gamification is the wrong word for the right idea. "What?s happening at the moment is Pointsification" [**?**]. She

criticized that the current use of gamification is a bad thing because it?s a misleading title for a misunderstood process. Points and badges are the least important bit of a game. She also pointed out: “Pointsification is a perfectly valid and valuable concept which nonetheless needs to be implemented carefully with due concern for appropriateness and for unintended consequences”.

Many considered the current efforts of gamification focus on extrinsic motivators (such as points, badges and rewards) instead of intrinsic motivators generated by an individual’s internal will or desires.

Nicole Lazzaro argued that the use of extrinsic rewards will decrease the motivation to use your products and services once you remove that reward [11]. Vockell resonated that in education psychology, extrinsic motivators may lead to short-range activity increase but reduction in long-range interest in a topic. While intrinsic motivators motivate people best when they are working toward personally meaningful goals [**?**].

Michael Wu argues that extrinsic rewards can jumpstart intrinsic motivation [**?**]. He claimed that gamification just has to work long enough for some other processes to take over as the primary driver of value. Subsequently, it becomes a secondary reinforcement system.

2.2.6 Gamification Design

This section describes the current approach in gamification design. It starts with gamification design 1.0 with simply adding point, badge and leader board in applications. In the end it discusses the smart gamification that emphasizes a player’s journey to mastery in an application.

Different game mechanics and elements can be used to serve different functions in satisfying players’ needs, and the basic elements such as point, badge, and leader board are the defining attributes of the current gamification practices [**?**]. Figure 2.9 illustrates these basic game mechanics and elements.

Seth Priebatsch stated that you can get anyone to do anything with 7 game dynamics [**?**]. Techcrunch published a “secret” game dynamics play deck that is used by Priebatsch’s company SCVNGR [**?**]. The play deck is a set of 47 flash cards. Each card illustrates one game dynamics. SCVNGR employees are instructed to memorize them and apply in their applications as needed. Social interaction designer Adrian Chan commented that the play deck does not include the sociological factors in social gaming and confuses game mechanics with game dynamics [**?**].

Gamification.org compiles a list of game mechanics and categories them into three types (Behavioral, Feedback, Progression) and their benefits [9]. Table 2.1 - 2.4 organizes the mechanics in type, a short description or examples, benefits, and possible player types in Bartle’s model [**?**]:

Table 2.1. List of Game Mechanics (source: gamification.org [9])

Types	**Mechanics / Examples**	**Benefits**	**Player Types**
Progression	Achievements: normally represents as badge, completed something	Engagement, Loyalty, Time Spent, Influence, Fun, SEO, UGC	Achievers, Explorers, Killers
Progression	Levels: a system of reward for a cumulation of points, Often are unlocked as players progress to higher levels.	Engagement, Loyalty, Influence, Time Spent, Virality, Fun	Achievers, Explorers, Killers
Progression	Points: a running numerical value given for any single action or combination of actions.	Engagement, Loyalty, Influence, Time Spent, Virality, Fun, UGC	Achievers, Explorers, Killers
Progression	Progression: success is granularly displayed and measured through the process of completing itemized tasks, such as a progress bar.	Engagement, Loyalty, Influence, Time Spent, Fun, UGC	Achievers, Killers
Feedback	Appointment Dynamics: at a predetermined times/places a user must return for a positive effect	Engagement, Influence, Time Spent	Archivers, Explorers, Socializers
Feedback	Bonuse: a reward after having completed a series of challenges or a specific task	Engagement, Influence, Time Spent, Virality, Fun, UGC	Archivers, Explorers, Socializers, Killers

Table 2.2. List of Game Mechanics (cont.)

Types	**Mechanics / Examples**	**Benefits**	**Player Types**
Feedback	Cascading Information Theory: information should be released in the minimum possible snippets to gain the appropriate level of understanding	Engagement, Loyalty, Influence, Time Spent	Archivers, Explorers, Socializers, Killers
Feedback	Combos: reward skill through doing a combination of things, usally comes with the reward of a bonus	Engagement, Influence, Time Spent, Virality	Archivers, Explorers, Socializers, Killers
Feedback	Countdown: players are only given a certain amount of time to do something. This will create an activity graph that causes increased initial activity increasing frenetically until time runs out, which is a forced extinction.	Engagement, Fun, Influence	Achievers, Explorers, Killers
Feedback	Quests/Challenges: Challenges usually implies a time limit or competition whereas Quests are meant to be a journey of obstacles a player must overcome. a way to organize player effort.	Engagement, Loyalty, Revenue, Influence, Time Spent, Virality, SEO, Fun, UGC	Achievers, Explorers, Killers
Feedback	Reward Schedules: The fixed or variable timeframe and delivery of the rewards, contingency, response, reinforcer.	Engagement, Loyalty, Revenue, Influence, Time Spent, Virality, SEO, Fun, UGC	Achievers, Explorers, Killers
Behavioral	Discovery/Exploration: players love to discover and to be surprised.	Engagement, Loyalty, Influence, Time Spent, Fun	Explorers, Achievers
Behavioral	Epic Meaning: Players will be highly motivated if they believe they are working to achieve something great, something awe-inspiring, something bigger than themselves.	Engagement, Loyalty, Influence, Time Spent, Fun	Achievers, Explorers, Socializers, Killers

Table 2.3. List of Game Mechanics (cont.)

Types	**Mechanics / Examples**	**Benefits**	**Player Types**
Behavioral	Free Lunch: getting something for free due to someone else having done work. Groupon	Engagement, Loyalty, Revenue, Influence, Virality, Fun	Achievers, Explorers, Socializers, Killers
Behavioral	Infinite Gameplay: do not have an explicit end, static state is its own victory.	Engagement, Loyalty, Revenue, Influence, Time Spent, Fun	Achievers, Killers
Behavioral	Loss Aversion: influences user behavior not by reward, but by not instituting punishment. the player having to perform an action to avoid losing something they currently have.	Engagement, Loyalty, Influence, Time Spent, Virality, Fun	Achievers, Explorers
Behavioral	Lottery: the winner is determined solely by chance. winners will generally continue to play indefinitely while losers will quickly abandon	Engagement, Loyalty, Revenue, Influence, Time Spent, Virality, Fun	Achievers, Explorers, Socializers, Killers
Behavioral	Ownership: creates Loyalty by owning things.	Engagement, Loyalty, Revenue, Influence, Time Spent, Virality, SEO, Fun, UGC	Achievers, Explorers, Socializers, Killers
Behavioral	Community Collaboration: an entire community is rallied to work together to solve a riddle, a problem or a challenge. Immensely viral and very fun.	Engagement, Influence, Time Spent, Virality	Archivers, Explorers, Socializers

Table 2.4. List of Game Mechanics (cont.)

Types	**Mechanics / Examples**	**Benefits**	**Player Types**
Behavioral	Behavioral Momentum: a tendency of players to keep doing what they have been doing	Engagement, Loyalty, Revenue, Influence, Time Spent	Archivers, Explorers, Socializers, Killers
Behavioral	Blissful Productivity: playing hard rather than relaxing makes you happier	Engagement	Archivers, Explorers, Socializers, Killers
Behavioral	Status: The rank or level of a player. Players are often motivated by trying to reach a higher level or status. Also relates to envy.	Engagement, Loyalty, Revenue, Influence, Time Spent, Virality, SEO, Fun, UGC	Achievers, Socializ-ers,Killers
Behavioral	Urgent Optimism: The desire to act immediately to tackle an obstacle combined with the belief that we have a reasonable hope of success.	Engagement, Fun	Explorers, Killers
Behavioral	Virality: more successful in the game if you invite your friends, the social check-in.	Engagement, Loyalty, Revenue, Virality, SEO, UGC	Socializers, Achiev-ers,Killers

	Reward	Status	Achievement	Self Expression	Competition	Altruism
Points	●	●	●		●	●
Levels		●	●		●	
Challenges	●	●	●	●	●	●
Virtual Goods	●	●	●	●	●	
Leaderboards		●	●		●	●
Gifting & Charity		●	●		●	●

(a) Satisfies Human Needs (source: Bunchball)

(b) Basic Mechanics (source: Deterding [**?**])

Figure 2.12. Gamification 1.0

Game Elements are different than mechanics. They manifest the game information to the player, usually as UI components. Table 2.5 lists some popular game elements and their examples:

By doing a research study of 15 hardcore gamers, 15 casual games, and 15 non-players, Nicole Lazzaro identified the four Keys to releasing player's emotions during play: "Hard Fun, Easy Fun, Serious Fun, and People Fun" [**?**]. Most of the popular games selected in their research created emotion in at least three of the Four Keys, thus she suggested that combining these four keys in the game design will make a deeply enjoyable game for a wide market.

Nicole Lazzaro described the "Four Keys to Fun" framework to design better engagement in games, especially the MSO (Massively Social Online) games [11]. Figure 2.10 illustrates the framework in more details.

Amy Jo Kim presented "Smart Gamification" which focuses on designing the effective "Player Journey" with intrinsic reward preferred over extrinsic reward [10]. Kim pointed out that game techniques are not equal to core experience and intrinsic values are greater than extrinsic rewards. Kim stated that "a good game take the player on a journey toward mastery". As illustrated in Figure 2.11 (a), when overtime players experience from newcomer and become regular and finally turns into enthusiast, they progress from novice to expert and last to master. When de-

Table 2.5. List of Game Elements (source: gamification.org [9])

Elements	**Description and Examples**
Activity Feed	shows players what has been taking place in the system overall and motivate the player to obtain the same achievement as others.
Avatars	unique representations for a player. shows a high emotional attachment between the player and the game. often customization and decoration are enhancement for higer engagement.
Easter Eggs	an intentional hidden message, in-joke.
Instances	are created for players to have a unique experience that is outside the normal experience. When a player creates a special unique page experience that allows to log into and view their unique content an instance has been created.
Leader boards	are a means by which users can track their performance, subjective to others. Leaderboards visually display where a user stands in regards to other users. Leaderboards can be broken down into several subcategories such as: Global, Friends, Relative, Isolated etc.
The Notifier	is a direct way to give the user direct feedback about their progress, change of status in the gameplay experience etc.
User Profile	displays a User's data about their activity on a website and can be used to tell the world and a community on the internet who they are.

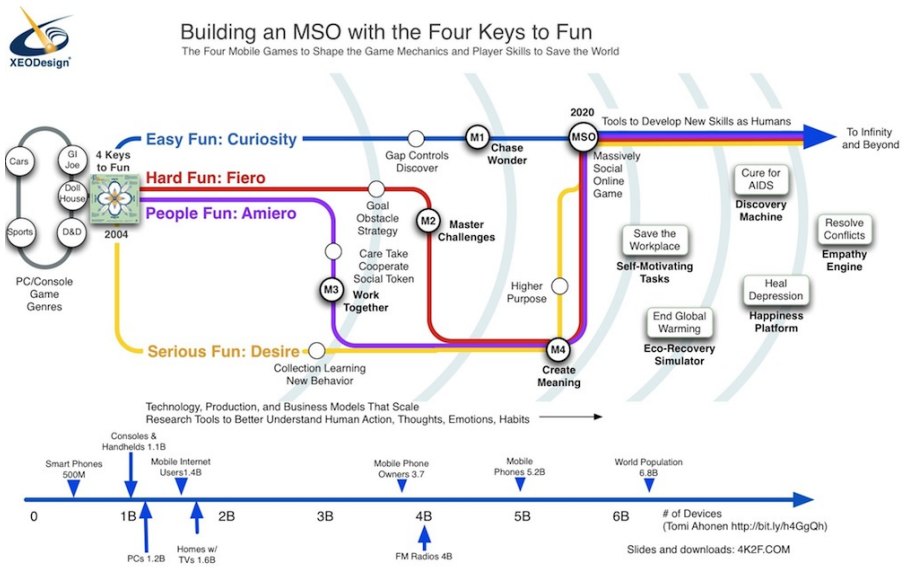
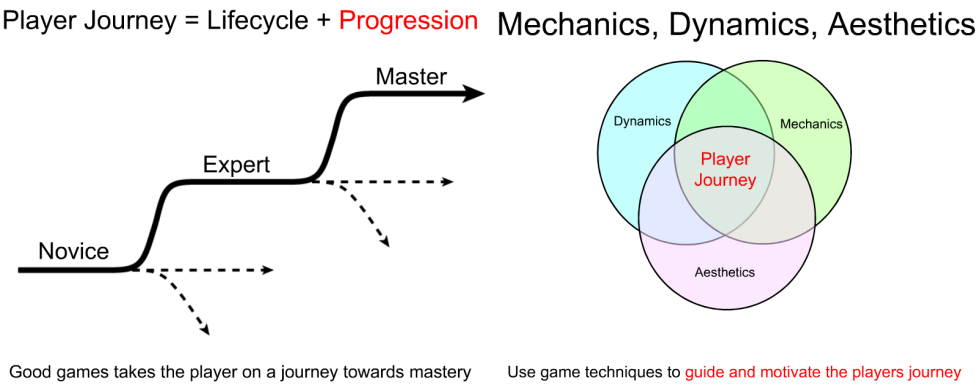


Figure 2.13. Four Keys to Fun Game Map (source: Lazzaro [11])

signing the journey, Kim suggests to use different techniques to meet players needs, where novices need onboarding, experts need fresh content, activities and challenges, and masters need exclusivity, recognition and impact. As shown in Figure 2.11 (b), Kim incorporates the MDA framework [**?**], using it to guide and motivate the player journey.



(a) Player Lifecycle (b) Game Design

Figure 2.14. Designing Player Journey (source: Kim [10])

Similarly, researcher Sebastian Deterding not only criticized the current practice of simple gamification practices but stressed the important of “meaningful play” and proposed a user experi-

ence design around the three most important aspects: Meaning, Master and Autonomy [**?**]. It is an adaptation to the three elements to motivate people in Daniel Pink's book "Drive: The Surprising Truth About What Motivates Us" [**?**]. Deterding explained that the reason why we play is because of the meaning and autonomy with choice in the game. The mastery in the game give us fun and enjoyment.

2.2.7 Gamification Services and Platforms

There are several gamification services and platforms from by commercial companies and open source providers. They aim to meet the increasing needs of gamifying non-game applications.

This section outlines the current industry players that provide gamification services via platforms or consultation services, as illustrated in Figure 2.12. Almost all of them are recent startups funded by venture capitals.

Figure 2.15. Gamification Service Industry

Here we take a brief look at the three most active players:

Badgeville [**?**] brands itself to be the world's leading Social Loyalty Platform. Its products include "Dynamic Game Engine", providing an easy and flexible way to setup behaviors, rewards, missions; "Gamification Widget Studio", offering a collection of skinnable and configurable game mechanics widgets; "Social Fabric", integrating social graph, social notification, relevant activity streams for better social engagement.

Bunchball's [**?**] Nitro Platform provides a comprehensive set of game mechanics, besides the normal points and badges levels, it provides Actions, Groups, Virtual Goods, Social networks,

Trivia, Poker, Comments etc. It is a fully integrated platform for engineers, designers, and marketers. Another product that Bunchball introduced is the Nitro Elements, which is a suite of cloud-based, simple plug and play applications, that is aimed for quick implementation of gamification. The current elements includes ”FanBox” (a reward system) and ”GameBox” (hosted poker game).

BigDoor [**?**] also provides a platform with flexible API and customizable widgets to add game mechanics to web sites, to reward users with points, badges, achievements and leader boards. The javascript based ”MiniBar” widget is a quick way to add game layer to the web site.

All of the above platforms feature built-in analytics built to provide some kinds of metrics about the result of the gamification. While Badgeville seems emphasize on social integration; Bunchball provides a comprehensive solution even with a game box; and BigDoor provides a simplest ”MiniBar” for easy non-technical integration into existing web site.

Open Badges [**?**] is a project of Mozilla with support from the MacArthur Foundation to provide a software infrastructure to making it easy to issue and display badges across the web. It uses shared badges as the recognition for all types of learning and achievement that take place anywhere, such as a skill learned from after-school program, a certification earned or simply an achievement of providing useful technical answers. The badges could be displayed in the personal or social web site, or being used in the job search as a convenient showcase of applicant’s qualification.

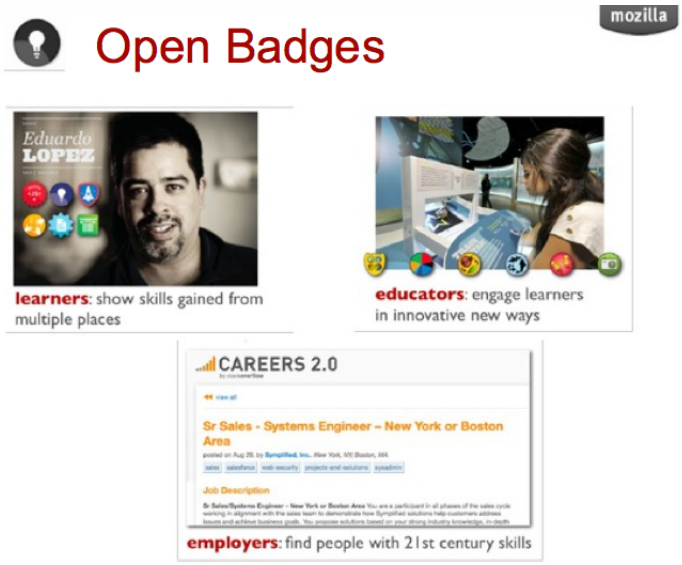


Figure 2.16. Mozilla - Open Badges Infrastructure

Userinfuser [**?**] is an open source platform that provides customizable gamification elements designed to increase user interaction on web sites. The project involves badging, points,

live notifications, and leader boards. Additionally, the platform provides analytics to track user participation. The current documentation shows the following widgets available in the platform.

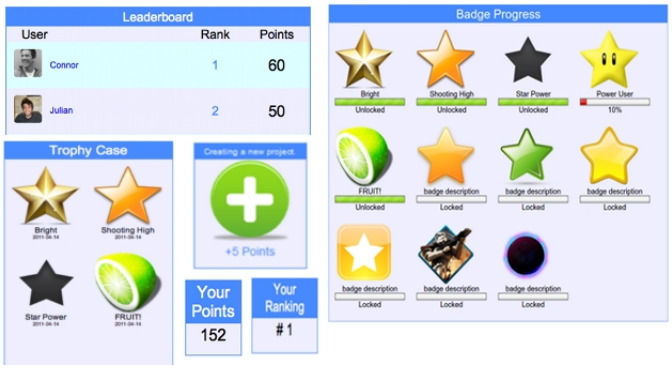


Figure 2.17. Open Source Gamification: Userinfuser Widget

Table 2.6 summarize the services provided by the platform discussed above.

Table 2.6. Summary of Gamification Platforms

Platform	Licence	Game mechanics	Analytics	Games
Badgeville	Commercial	Yes	Yes	No
BigDoor	Commercial	Yes	Yes	No
Bunchball	Commercial	Yes	Yes	Yes
Open Badges	Open Source	Yes (only badges)	No	No
Userinfuser	Open Source	Yes	Yes	No

2.3 Serious Games and Related Concepts

As we discussed before, gamification's main driving force is motivation. Serious games also try to solve the motivation problem and influence people's behavior. Deterding illustrates the distinctions between gamification, serious games and other related concepts, As shown in Figure 2.15 [6].

According to Deterding, a) Gamification is about game. It is different than playful interaction, playful design. b) Gamification uses game elements. It is not the complete game such as a serious game. c) Gamification applies to non-game context. Similar to serious game, it uses game

Figure 2.18. Serious Game and Gamification (source: Deterding [6])

for other purposed than game's normal expected use for entertainment. d) Gamification focuses on design. It is not game-based technology or practice of wider game ecology.

The following sections discusses serious games and related concepts in more details.

2.3.1 Serious Game

A Serious game is a complete game designed for a primary purpose other than pure entertainment [**?**]. It includes categories such as educational games and advergames (advertising), political games, and training game (also known as game-learning). Zyda (2005) defines serious game is "a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health,etc".

One example is Fold.it, which made the headline [**?**] by using game play to help solve problems that computers cannot solve very well, in this case, online gamers were able to do what biochemists have been trying to do for a decade: decipher the structure of a protein that is key to the way HIV multiplies.

Blending of real and virtual worlds has been explored in broader contexts. McGonigal designed the award winning serious Alternative Reality Game (ARG) "World Without Oil" [**?**] and later "Evoke" [**?**] with the goal to empower people to come up with creative solutions to our most urgent real-world problems. ARGs have also been used to support learning. Connolly et al. discuss the development of an educational ARG to motivate secondary school students across Europe to learn foreign languages [**?**]. The results of the pilot run of the game in 2009 indicated that 92% of

students felt the game motivated students to learn a second language. One of problems the team identified is the limitation of Moodle platform the game is based on.

The report of the ARGOSI project provides insights to the use of ARGs in game based learning and the challenges in the field of higher education [**?**]. The pilot was run at the University of Bolton with the aim to provide an engaging alternative to traditional methods of introducing students to university life. The overall up-take of the game was fairly low with 173 players and 23 (13%) of whom were active. The project identifies a number of questions surrounding educational ARGs, such as motivation, relationship to curriculum, marketing and timing. The report suggests that a complete ARG model may not be appropriate for wholesale learning, but there is certainly potential in using game elements.

The difference between Gamification and Serious game is not very clear. Both are trying to solve a problem with game thinking. Some reference serious game such as Foldit as a victorious example of gamification in science [**?**]. Sebastian Deterding's definition [6] illustrates that gamification are total different than serious game.

It is interesting to see that although the concept of serious games has been around since long before gamification, gamification has arguably steps into the mainstream whereas serious games stay in much smaller scale.

2.3.2 Persuasive Game

The term "Persuasive game" is introduced in the title book "Persuasive Games, The Expressive Power of Video games" by Ian Bogost [**?**]. In the book, Bogost argues that video games have a unique persuasive power that goes beyond other forms of computational persuasion. Not only can video games support existing social and cultural positions, as in Serious games, but they can also disrupt and change those positions, leading to potentially significant long-term social change, as in Persuasive games.

Persuasive game is closely tied to Persuasive Technology, designed to change attitudes or behaviors of the users through persuasion and social influence, but not through coercion [**?**].

Loren Baxter [**?**] posted that persuasive design, the use of psychology in design to influence behavior, could benefit UX design in a new level, hinting the use in gamification design as well.

2.3.3 Gameful Interaction Design

According to The Interaction Design Association (IxDA) [**?**], Interaction design defines the structure and behaviors of interactive products and services, and user interactions with those products and services. It is design principle with main focus on behavior. [**?**].

For example, the ”SmartGauge” dashboard for Ford’s hybrid cars, where a digital plant is responding to how energy-efficient the users driving behavior is [**?**]. The design gives drivers a game like interaction that for them, the game to grow more lush and beautiful leaves, a visual reward, by driving efficiently, desired behavior.

Another great example is the ”Piano Staircase” created by Volkswagen Sweden and ad agency DDB, installed in a metro station in Stockholm [**?**]. The design is to make the staircase next to the escalator look and respond like a piano keyboard, so that every step on the stair will generate different piano sounds every time a commuter walked on it. Observation indicates that 66 percent more people chose the staircase over the escalator, a good example of a ”Fun Theory” design for persuading and encouraging energy-efficient behavior.

(a) Efficiency Leaves (b) Piano Stair vs. Escalator

Figure 2.19. Examples of Gameful Interaction Design

The goal of such gameful interaction design is to achieve a certain influence, a change in the behavior of their users not through a mode of informative feedback and rational processing, but through the activation of emotion or sensibility.

2.4 Game Engine

Game engine, as defined by Lewis and Jacobson in Game engine in scientific research (2002), is ”collection of modules of simulation code that do not directly specify the game?s behavior

(game logic) or game?s environment (level data)". Sherrod defines it as "a framework comprised of a collection of di?erent tools, utilities, and interfaces that hide the low-level details of the various tasks that make up a video game".

Benefit of a game engine is to provide the building blocks for a game, enable the game developer to focus on game contents and results instead of the details on the infrastructure. The output of using a game engine is spending shorter time to create new games.

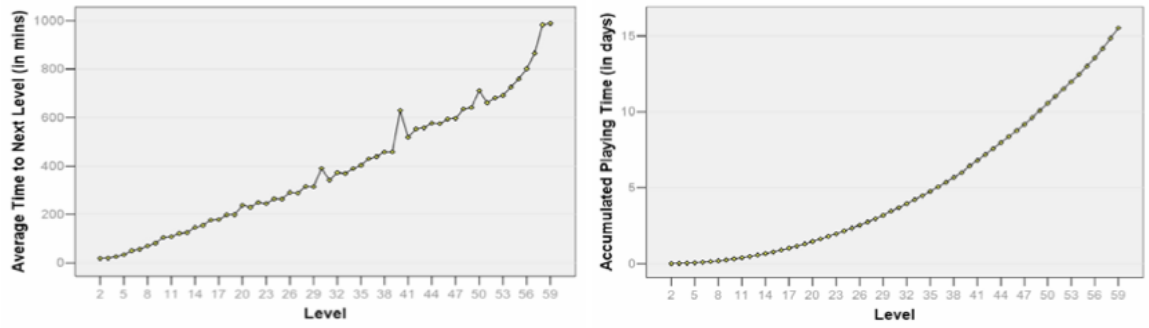
The examples of game engine includes:

- FPS: Unreal (rendering, physics, AI)
- Mobile: Papaya
- Healthcare: OpenLabyrinth
- Educational storytelling: Fabula

As far as my research in literature, I had not found any game engine for sustainability.

2.5 Game Analytics

Ducheneaut et al. provides a good example of using game metrics for analysis of player's experience in a quantitative approach [7]. They reported the relationship of playing time and leveling in the MMORGs, as shown in Figure 2.18:



(a) Average time required to reach a level

(b) Average accumulated play time by level

Figure 2.20. Player Metrics (source: Ducheneaut [7])

Game metrics could be as important as creativity in game design. As Nadia Oxford points out, in the social game industry, player metrics collection and analysis are widely practiced to

provide game designers to determine what the player audience likes and dislikes about a certain game experience [**?**].

This section reviews what kinds of the metrics and analytics could be employed in gamification and serious game design.

2.5.1 E-Score

E-Score is introduced by Gabe Zichermann, mainly applies in marketing gamification [**?**]. These are the metrics that go into the score:

- Recency : How long ago did they visit?
- Frequency : How often did they come back?
- Duration : How long did they stay?
- Virality : How many people have they told about you?
- Rating : What did they explicitly say when asked about you?

2.5.2 Social Game Metrics

Matt Fairchild lists and explains the basic terminology for social games metrics [**?**]:

ARPU: Average Revenue Per User (ARPU) is measured as total revenue divided by the number of subscribers. This includes revenue from subscriber fees, virtual goods, affiliate marketing and ad impressions. Because social games are so metrics-heavy, ARPU can be broken down by day, by country, by demographic, or by pretty much any other metric.

Churn: The turnover rate (or ?attrition rate?) of a social game?s active players. Churn refers to the constant loss and gain of members, especially high in casual gaming.

Cohort: Cohorts are used for analyzing retention. By organizing users in groups such as "everyone that visited on June 10th" and analyzing the percentage that revisit, you can pinpoint what promotions are having the greatest effect.

DAU: Daily Active Users (DAU) is the number of active users over the course of a single day.

DAU/MAU: Comparing Daily Active Users to Monthly Active Users shows roughly how many days per month the average user engages with a game. The DAU/MAU ratio is strongly correlated with social gaming success.

Engagement: Engagement measures how long users spend playing a game. How many features do they access? Are they spending hours or seconds? How many pages does the average user view? What percentage are returning visitors?

Entry Event: An entry event is the first action a user performs when he enters the game. What do users do first? Which entry events are the most effective at bringing people back? By determining the more popular entry events, you can push more resources towards them, thus increasing retention, engagement and re-engagement.

Exit Event: Exit events are the last actions a user performs before exiting the game. Tracking the Exit Event Distribution helps show why users are disengaging with the game.

K Factor: K Factor measures the virality of a game. K Factor = (Infection Rate) * (Conversion Rate). An Infection Rate is how much a given user exposes the game to other players, such as through status updates or email invites. A conversion rate is when that "infection" results in a new sign up. A high K Factor indicates effectiveness of bringing in new players.

Lifetime Network Value: The value a user provides to your network over the course of his entire "lifetime" on the network. For instance, is the user contributing to viral effects, evangelizing the game or contributing positively to ARPU? This is compared to the User Acquisition Cost, or how much it costs (via marketing and viral efforts) to bring in new members.

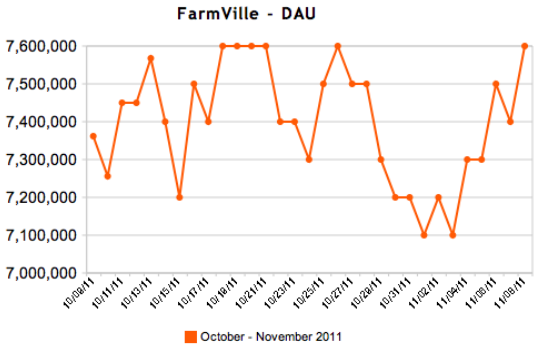
MAU: Like DAU, Monthly Active Users (MAU) tracks the total number of users in a given month.

Re-Engagement: Re-engagement is about how to get users back. It includes re-engaging gamers who have been signed off for an hour, a day, a month, or more.

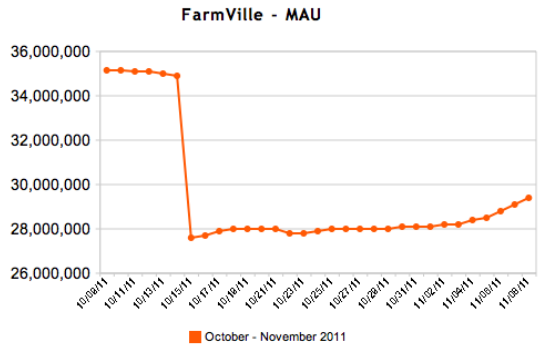
Retention: Retention is how well you maintain user base, as the opposite of churn.

Appdata.com gathers independent application metrics from most of the social game application. For example, the graphs in Figure 2.19 shows the DAU (Daily Active User) and MAU (Monthly Active User) metrics for the popular Farmville social game [2]:

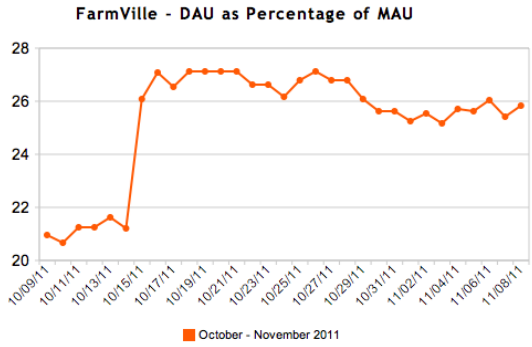
Kontagent, a user analytics service company, introduces the top 10 social game metrics [**?**]: (1) Entry Event Distribution. (2) Outbound Messages/User. (3) Viral Message CTR/Conversion. (4) Virality (K-factor). (5) Engagement. (6) Exit Event Distribution. (7) Retention - Revisit Rate. (8) Lifetime Network Value. (9) Conversion to paying users. (10) Average Revenue Per Paying User.



(a) FarmVille DAU



(b) FarmVille MAU



(c) FarmVille DAU/MAU

Figure 2.21. Social Game Metrics (source: Appdata.com [2])

2.5.3 A/B Testing

A/B testing is often part of the services from analytics solution providers. For example, Google's Website Optimizer [**?**] can be combined with Google Analytics to provide in-depth A/B testing experiments and data analysis.

A/B testing, also called controlled experiment, is data-driven evaluation methodology recently employed by researchers and game industries to support game design decisions [**?**]. In A/B testing, two conditions are randomly presented to users in the same population and see how they response. For example, Zynga used this approach to collect player metrics in different conditions and found that pink fonts caused players to click on an advertisement for PetVille far more often [**?**].

Andersen et al. at the Center for Game science of University of Washington describe several A/B testing research in evaluating games. Using a series of large-scale A/B tests, they found that music and sound effects had little or no effect on player retention in the two popular Flash games they developed, while animations caused users to play more [**?**]. The results of their another A/B testing study of over 45,000 players show that the usefulness of game tutorials depends greatly on game complexity. In simpler games, tutorials did not significantly improve player engagement; while in complex game, they increased play time by as much as 29% [**?**].

Chapter 3

System Design

Makahiki, represents research intended to create synergy between the need to create knowledge and engagement regarding energy and the ability of so-called "serious game" techniques and energy feedback to create participation and engagement [6, 5, 8, 15]. In Makahiki, online game mechanics are employed with the goal of affecting real-world energy behaviors [3]. The ultimate goal is to not just affect energy behaviors during the course of the game, but to produce long lasting, sustained change in energy behaviors and outlooks by participants. Figure 3.1 illustrates the architecture of Makahiki.

Makahiki consists of a configurable game engine that can be customized to the needs of different organizations. It includes a library of pre-built game "widgets" that implement a variety of game mechanics. Using the widgets, an organization can create a custom energy challenge in which players can compete individually and/or in teams to earn the most points by reducing their energy consumption as well as by learning about energy concepts in general. The next sections present some of the most important widgets in Makahiki.

3.1 Configurable Game Elements

3.1.1 Smart Grid Game

The Smart Grid Game widget shown in Figure 3.2, is the primary place players go to learn about energy issues and earn points. Actions are organized into a grid of squares (hence the name "Smart Grid") and organized by category columns. The game supports levels so that a large number of actions can be presented in a sequence of smaller grids. Each grid contains four different types of actions: activities, commitments, events, and excursions.

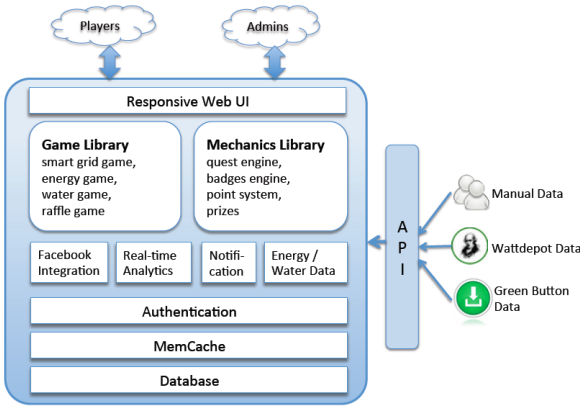


Figure 3.1. Architecture of Makahiki

Activities are the most basic actions available in the Smart Grid. In order to get points for an activity, a player will have to provide a response to the administrators. These responses can be a short textual answer or an uploaded picture. Administrators access a special section of the web application to approve or deny submissions. If a submission is approved, the player will receive points, as well as website notification about the approval. If a submission is rejected, the player will be sent a website notification informing them that their submission was not approved, and a textual description by the administrator of why it was rejected. The player can change and resubmit their response and still earn the full point value for that activity.

Commitments are pledges that the player will do something related to energy or sustainability for a period of five days. Examples include: reducing shower time, taking the stairs, and turning off the lights when leaving a room. Although these commitments are not verifiable, they are public and visible to other players in the same team and worth fewer points than activities. Furthermore, a player is limited to five active commitments at any given time. After the five day period is up, the player can then declare that they completed the commitment and immediately earn their points. They can then sign up for another commitment, including the one they just completed.

Events and excursions are tied to real world activities. Events are held locally while excursions require transportation. Seating is limited, so players are asked to sign up for events or excursions they wish to attend. Players that do so are provided with a 2 point signup bonus. Players can also set up a reminder that is sent to their email and/or their mobile phone before the event takes place. At the event, an administrator will hand out attendance codes printed on slips of paper that can be entered on the website. These attendance codes are generated by Makahiki and can only be

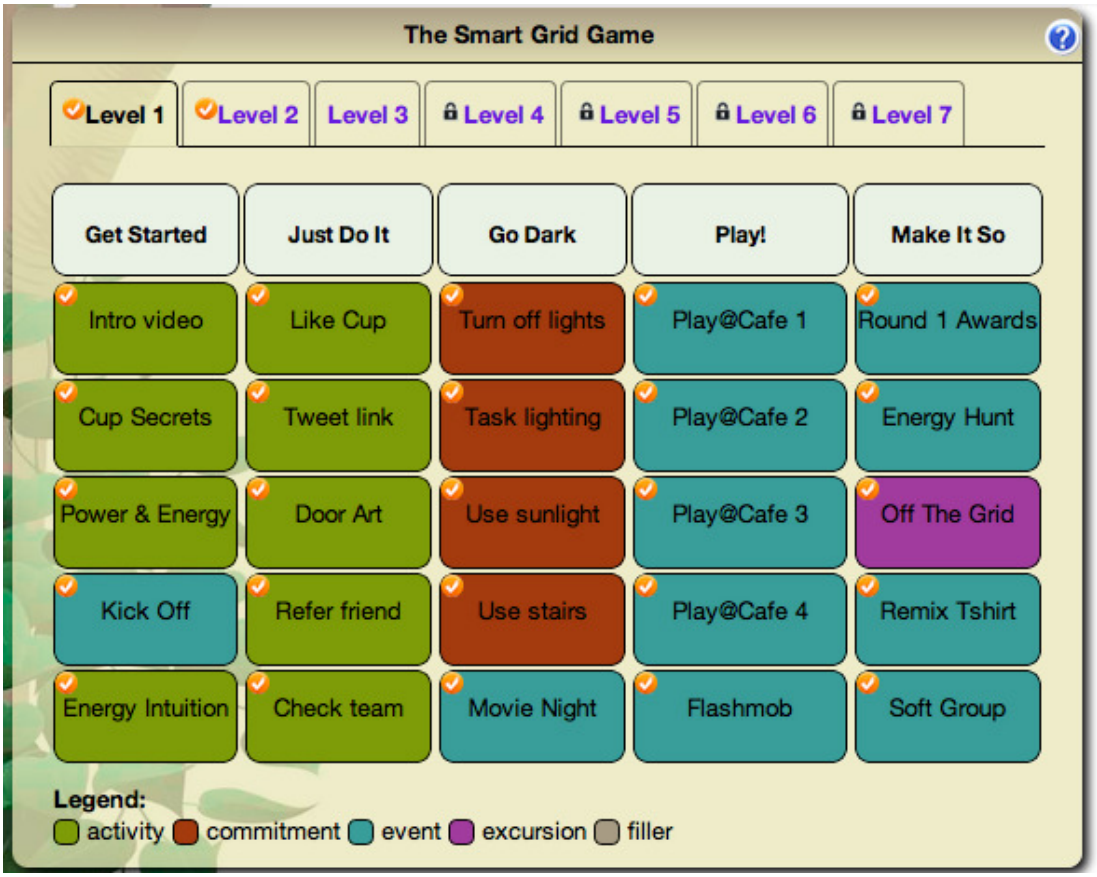


Figure 3.2. *Smart Grid Game widget*

used once. To discourage players from signing up and not attending, a 2 point penalty is applied to players who do not submit an attendance code. If the player submits an attendance code for the event after receiving this penalty, the penalty is reversed.

Not all of the actions and levels in the Smart Grid Game are necessarily available at the start of the game. We provide a set of predicates that can be used to determine if an action or level is locked or unlocked for a player. These predicates include: completed a certain number of actions within a category, completed all actions within a category, completed a certain action, and unlocking of an action or level after a certain date.

These predicates are implemented using a limited subset of Python and can be changed within the administrative interface. Challenge designers can use logical operators to combine any of these functions in order to organize the players' path through the Smart Grid Game.

3.1.2 Power Meter

A fundamental requirement for enabling more active participation by consumers in the smart grid is feedback regarding their energy usage. One of the most simple mechanisms provided by Makahiki for this purpose is the Power Meter widget, illustrated in Figure 3.3.

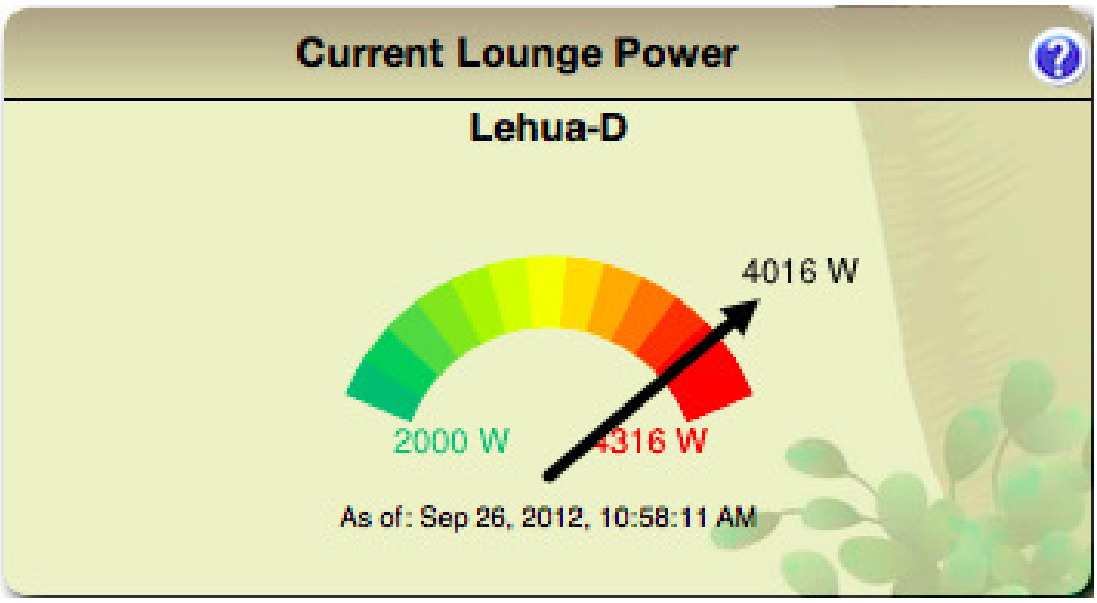


Figure 3.3. *Power Meter widget*

The Power Meter widget provides basic feedback on energy consumption via a display of the team's power consumption, updated every few seconds. The visualization can normalized using baseline values so that when the needle is pointing straight up, the power consumption is the average for that team during that specific hour of that specific day of the week. Thus, if the needle leans left toward the green side, the team's power consumption at that moment in time is below average, while if the needle leans right toward the red side, the team's power consumption at that moment in time is above average.

The Power Meter widget obtains its values by querying the WattDepot system for the latest power data consumed by the associated team. The use of WattDepot, rather than directly querying the meter(s), simplifies the widget design significantly. First, the physical meters can vary significantly in the protocol implemented to obtain current power consumption. These protocol variations are handled by the WattDepot sensors, so this widget can simply query the WattDepot server using a single HTTP request that is independent of the physical meter characteristics. Second, the power consumed by a team might be measured by one or multiple meters. Again, the WattDepot source

aggregation capability means that this physical difference can be abstracted away by WattDepot, enabling the widget to obtain the aggregate power for the team through a single HTTP request.

The Power Meter widget is a useful, though simple mechanism for energy feedback that uses the WattDepot+Makahiki stack. The next section presents a more sophisticated mechanism called the Daily Energy Goal Game.

3.1.3 Daily Energy Goal Game

The Daily Energy Goal Game widget provides a way for players to earn points by reducing their current energy consumption from a baseline. This baseline can be calculated using historical data or dynamically throughout the competition. Both the baseline data and the current consumption is typically provided by API calls from Makahiki to an underlying WattDepot server. Figure 3.4 illustrates this widget.

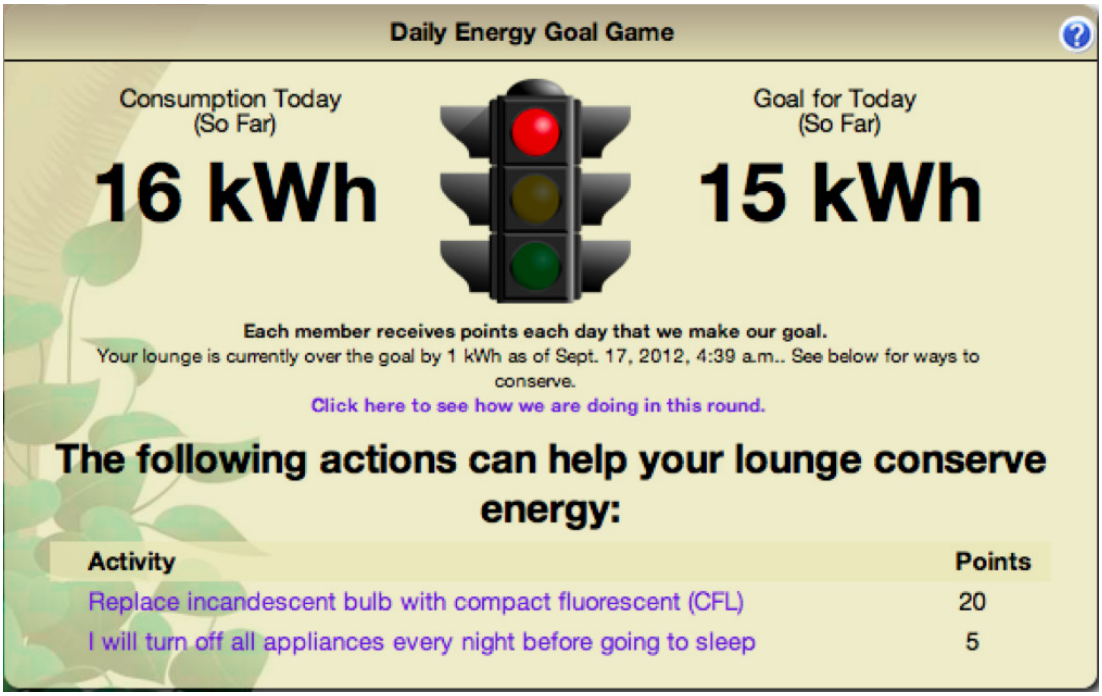


Figure 3.4. *Daily Energy Goal Game widget*

The goal for each team is typically a percent reduction from their baseline usage. When a player goes to the energy page of Makahiki, they can view their team's current progress toward their daily energy goal. Near the end of the day, Makahiki checks the energy data from Wattdepot to see if a floor reached their goal. If the floor did reach their goal, each member of the floor that is

participating in the game receives points. The energy goal game provides a link between the energy conservation competition and the point competition.

The Daily Energy Goal display shows both their current progress and their goal so far. We have noticed that our participants use more energy at night rather than during the day. Thus, it is easy to be under their actual energy goal for most of the day and then jump over the goal at the very end. Displaying their progress toward the goal so far provides a pace for players to follow.

3.1.4 Raffle Game

The Raffle Game widget provides a way to incentivize participation from all individuals, even those who are not in the running for a top prize. For every 25 points a player earns, they receive one virtual raffle ticket. Players can dynamically allocate their tickets to any raffle prizes they are interested in at any time, up to the end of the raffle. Figure 3.5 shows an example of the Raffle Game.

Figure 3.5. *Raffle Game widget*

Each round of the competition has its own set of raffle prizes and any unused raffle tickets carry over to the next round. Raffle tickets are independent from a player's score, and allocating a raffle ticket does not affect their rank. The system provides random selection of the winner of each raffle item at the end of a round.

3.1.5 Social and Referral Bonuses Game Mechanics

The Social and Referral Bonus widgets are the game mechanics that help encourage participation by providing additional points to players who participate in activities with other players, and facilitate the entry of new players into an energy challenge.

The social bonus is an configurable option when an action is created in the Smart Grid Game. Players earn extra points if they perform the action with another player. Examples of actions with a social bonus include attending an event, recording a song related to energy, or measuring a shower water flow rate. When a player submits a response for an action with a social bonus, the player can provide the email address of the person who jointly completed the action. Once the other player completes the action, the social bonus is awarded. Social bonuses are not bi-directional; if the second player doesn't provide the first player's email address, only the first player will get the social bonus.

Players are led through a setup process when logging into Makahiki for the first time. One of the steps in this process is the referral bonus. If a player was referred by another player in the system, they can use this step to input their email address. Once the new player earns a certain number of points in the competition, both players are awarded a referral bonus of a configurable number of points. Typically, going through the setup process gives you 25 points, so setting a point threshold of 30 points encourages the new player to at least complete one additional action in order to get the referral bonus.

3.1.6 Quest Game Mechanics

One challenge we faced when designing Makahiki was providing adequate help to the player. The game needed to be intuitive, even if a new player is not familiar with energy challenges. Unlike many web applications, such as email, Makahiki players generally do not know in advance what specific actions they wish to accomplish. In an effort to provide a player with guidance through Makahiki after the setup process, we implemented the Quest Engine. Quests are used to guide the player through the various workflows of the site, such as completing a action, signing up for an

event, or allocating a raffle ticket. These quests can be created using the administrative interface. Quests use a set of predicates to determine unlock and completion conditions. These predicates include: participating in a action or type of action, completing an action or type of action, having a certain number of points (in a round or overall), completing a certain number of actions in a category or of a given type, being awarded a badge, and adding a picture to their profile.

3.1.7 Badge Game Mechanics

3.2 Real-time Analytics

Makahiki is designed to support energy challenges involving hundreds or thousands of users lasting weeks or months. In these circumstances, effective use of the technology requires the ability to understand the state of the game, such as: Who is using it? What are they doing? What is the player response to activities, commitments, excursions, and events? Such state information is important for planning purposes, such as assessing the transportation needs for an upcoming excursion by seeing how many players signed up. It can also be used for making in-game changes to game design, such as changing the point values associated with activities to encourage or discourage participation. It can also help identify breakdowns in game play, such as significant numbers of unallocated raffle tickets indicating that users do not understand the nature of that game mechanic.

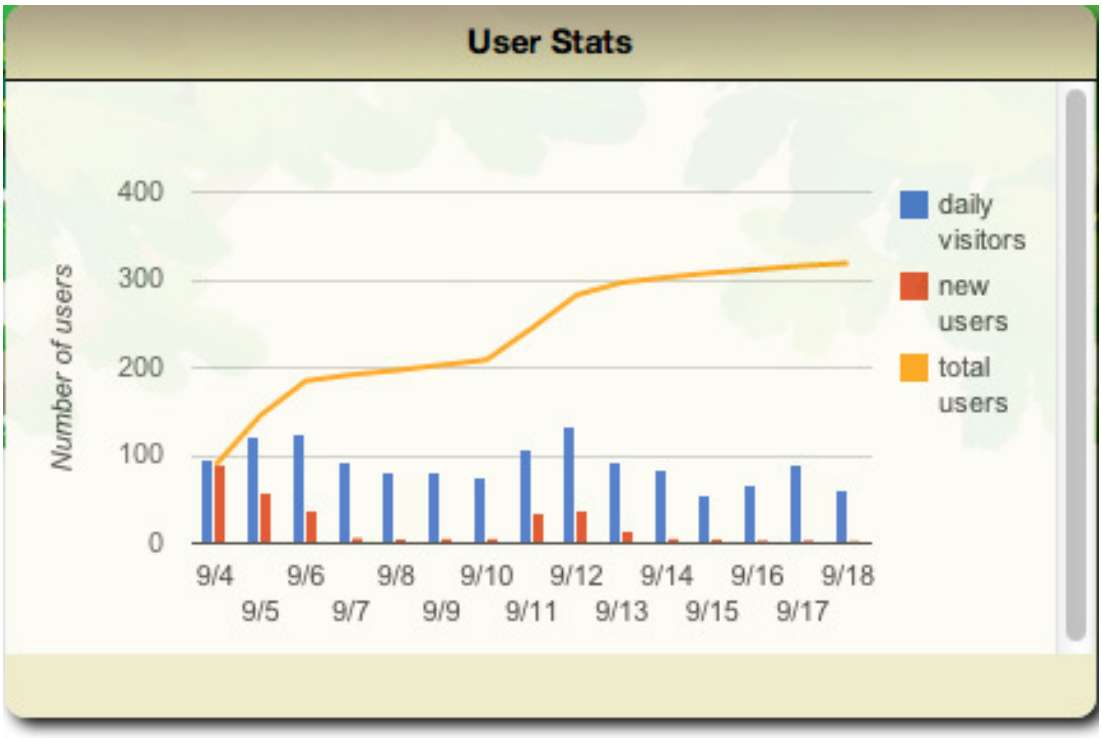
To address these needs and others, Makahiki includes a variety of widgets that work together to provide high level overview of game play state to the administrators of a challenge. Figure 3.6 shows an example of two game analytic widgets.

The top widget, User Stats, shows trends in the total number of players, the total number of new users, and the total number of players visiting the site each day. The bottom widget provides information on the ability of teams to achieve their daily energy goal each day and over time.

3.3 Configurable resource

3.4 Mobile support

3.5 Cloud deployment support



Energy Goal Status

Team	09/16	09/15	09/14	09/13	09/12	09/11	09/10
Lehua-A	-16 87	-2 87	-5 86	-9 87	-8 85	-5 88	-3 87
Lehua-B	-14 101	-7 100	-14 100	-11 101	-12 100	-9 104	-13 99
Lehua-C	-9 91	-2 85	-4 90	-5 92	-4 92	-2 94	-9 92
Lehua-D	-1 94	0 91	-1 92	0 95	2 98	2 97	2 99
Lehua-E	-14 82	-6 77	-4 85	-12 88	-6 91	-4 92	-13 86
Ilima-A	-14 87	-6 89	-5 87	-13 85	-8 87	-13 86	-15 83

Figure 3.6. Game analytic widgets: User Stats and Energy Goal Status

Chapter 4

Evaluation Framework

This chapter describes the evaluation framework that can be used to access the effectiveness and efficiency of an IT infrastructure for the development of serious games for sustainability. It starts with the discussion of evaluation methodology, and is followed by the proposed evaluation framework.

4.1 Evaluation Methodology

This framework emlpoys a mixed method of case studies, with qualitative and quantitative data analysis. The qualitative analysis includes a set of interviews that will be administrated to the users of the system to gain insights about their experiences of their interaction of the system. The quantitative analysis mainly involves using the analytics data recorded by the system, such as website logs, player interaction logs, feedbacks, resource usage, etc.

4.2 Definition of effectiveness and efficiency

Before describing the approach of the evaluation framework for IT infrastructure for serious games for sustainability, here we define the terms of effectiveness and efficiency in the context of serious games for sustainability.

- *Effectiveness:* We define the effectiveness of an IT infrastructure for serious games for sustainability is that the IT infrastructure can produce the desired changes in player behavior, which reduces resource consumption

- *Efficiency:* We define the efficiency of an IT infrastructure for serious games for sustainability is that the IT infrastructure can support design, management, administration, development, and improvement for serious games for sustainability

4.3 Evaluation Mechanism

A serious game for sustainability normally includes real-world activities and components, such as going out for a educational excursion about sustainability, installing smart meters to measure energy consumption, giving out prizes to the winners of the game, etc. There are more stakeholders in a serious game for sustainability than other kinds of serious games or entertainment games. We consider a list of stakeholders for a serious game for sustainability includes:

- Players: the users who participate in the game play.
- Game Designers: the admin user(s) who design the content and game mechanics
- Game Managers: the admin user(s) who manage the game during the period of the game, such as approving submission, inputing manual energy data, notifying prize winners, etc.
- System Admins: the IT person who installs and maintains the game system
- Developers: the person(s) who extend, enhance and debug the system.
- Researchers: the person(s) who doing research with the system.
- Spectators: persons who do not participate in the game play but know about and interested in the game.
- Community partners: persons or organizations who partner with the game organziers to help the real-world events of the game.
- Facilities: persons or organizations who are responsible for facilitating the energy and water meter installation and data collection.
- Funding organizations: the organizations who provide funding to the project.

The success of a serious game for sustainability depends on all the stakeholders. Due to our interest only in the evaluation of an IT software infrastucture, we will exclude the evaluation of

spectator, community partner, facilities, and funding organizations. They are important stakeholders that contribute to the success of the serious game, but does not constribute the experience of evalauting the effectiveness and efficiency of the IT infrastrucutre.

The evaluation framework I propose is to evaluate the following stakeholders' experience with the system, and to determine the extent to which the system is effective and efficient with respect to the role of these stakeholders:

- Players
- Game Designers
- Game Managers
- System Admins
- Developers
- Researchers

We will discuss in details in the following sections for each role in question:

4.3.1 Player effectiveness

There are three research questions to be investigated for the evaluation of player effectiveness:

- To what extent does the system engage players?
- To what extent does the system increase player's literacy in sustainability?
- To what extent does the system produce positive player behavior change in sustainability?

A serious game should include detailed log data for the players' interaction with the game. These are the engagement metrics I propose to measure the player engagement for a serious games for sustainability:

- active participation rate
- number of players per day
- average session time

- submissions per day
- level of social engagement
- website errors

Pre-game and Post-game survey: Randomly selected eligible players Compare result from pre-game and post-game Compare non-players (control group) and players Literacy survey design from Robert Brewers dissertation

Expected result if literacy increase: no change in literacy for non-players changes in literacy for active players

Resource consumption measurement: Establish/calculate daily/hourly baselines prior to and during the game Compare daily/hourly in-game usage to baselines Compare post-game usage to baseline and in-game usage

Player feedback from in-game survey: Did you notice your behavior changes during and after the game? Did you continue the commitments you did in the game?

Expected result if positive behavior change: resource usage decrease compared to baselines self-report some level of positive behavior changes

4.3.2 Game designer efficiency

The research question to be investigated for the evaluation of game designer effectiveness is:

- How efficient is it to design a game using the system?

Usability metrics from usage log: time spent to configure global settings time spent to set up player data time spent to design individual game elements errors encountered

Interview the designer to answer: How much time did you spend to configure the global settings, player data, and individual games? What problem did you encountered? Did you find it difficult to configure? what is difficult? Did you find it difficult to design a specific game? which one, what is difficult? What did you like the least when using the system? Expected result if it is efficient for designer: The log data co-relates to interview results time spent is relatively short subjective opinion from designer is easy to use

4.3.3 Game manager efficiency

The research question to be investigated for the evaluation of game manager effectiveness is:

- How efficient is it to manage the game using the system?

Usability metrics from usage log: time spent to managing player submissions if any time spent to monitoring the game state time spent to entering usage data if manual input needed time spent to notifying winners of the games errors encountered Interview the game managers to answer: How much time did you spend to managing player submissions? How much time did you spend to monitoring the game state, notifying the winners, entering the manual data? What problem did you encountered? Did you find it difficult to manage? what is difficult? What did you like the least when using the system? Expected result if it is efficient for manager: The log data co-relates to interview results time spent is relatively short subjective opinion from manager is easy to use

4.3.4 System admin efficiency

How efficient is it to install and maintain the system?

Interview the system admin to answer: How much time did you spend to install if hosted locally? How much time did you spend to deploy if hosted in the cloud? How much time did you spend maintaining the system locally or in the cloud? What problem did you encountered? Did you find it difficult to admin the system? what is difficult? What did you like the least about administrating the system?

Expected result if it is efficient for system admin: time spent is relatively short subjective opinion from system admin is easy to use

4.3.5 Developer Efficiency

How efficient is it to understand, extend and debug the system?

Code analysis/review from developer project: Compare to ?expert? implementation: (lines of codes, bugs, number of API calls) Software development metrics: numbers of check-ins numbers of CI build/test failure Interview the developers to answer: How much time did you spend to set up the dev env? How much time did you spend to develop and debug an enhancement? What problem did you encountered? Did you find it difficult to understand, extend and debug the system? what is difficult? What did you like the least when developing with the system?

Expected result if it is efficient for developer: time spent is relatively short small numbers of bugs lines of codes/number of API calls similar to ?expert? implementation small numbers of build failure subjective opinion from manager is easy to use

Evaluation Design

Two weeks individual student developer project using Makahiki:

Setup the development environment (follow documentation and go through helloworld widget tutorial)

Develop an enhancement: ?group competition?

Check in often (at least weekly), which triggers CI build with minimum acceptance test suite

Review the project submission

4.3.6 Researcher Efficiency

How efficient is it to do research with the system?

Interview the researcher to answer: How much time did you spend to collect the research data? What problem did you encountered when collecting and analyzing data? Did you find the data you collect helpful to your research? if not, what can be improved? Did you find it difficult to collect and analyze the data from the system? what is difficult? What did you like the least about using the system?

Expected result if it is efficient for system admin: time spent is relatively short the data is useful subjective opinion is easy to use

Chapter 5

Evaluation

This chapter describes the experimental design for two evaluation tasks: (1) applying the evaluation framework described in Chapter 4 to the Makahiki system described in Chapter 3, (2) applying the evaluation framework described in Chapter 4 to a second IT infrastructure for serious games for sustainability.

To applying the evaluation framework described in Chapter 4, we propose to investigate the following research questsions:

- *To what extent does the system effectively enage players?*
- *To what extent does the system effectively increase player's literacy in sustainability*
- *To what extent does the system effectively produce positive player behavior change in sustainability?*
- *How efficient is it to design a game using the system?*
- *How efficient is it to manage the game using the system?*
- *How efficient is it to install and maintain the system?*
- *How efficient is it to understand, extend and debug the system?*
- *How efficient is it to do research with the system?*

5.1 Makahiki Evaluation

I propose to evaluate the Makahiki system in two ways: (1) case studies of Makahiki instances in real-world, namely the three Kukuicup serious games deployed in University of Hawaii at

Manoa, Hawaii Pacific University, and East West Center of Hawaii. (2) in-lab experiement of evaluting Makahiki system by the students taking the serious game development course in the Universiy of Hawaii at Manoa.

5.1.1 Real-world Makahiki Case Studies

Can Makahiki be successfully deployed in multiple organizational scenarios to provide games for major sustainability issues (energy, water, etc.)?

5.1.1.1 Player experience evaluation

Can Makahiki provide an engaging and fun learning user interface to its end users?

I plan to perform End User Evaluation with in-game survey and aggregated analytics from the logging data collected from all sites.

The *in-game survey* will be implemented as an activity action in smartgrid game in the challenge. Players can earn points by completing the survey action. We will use SurveyGizimo to create the survey which consists of a series of questions about the players' experiences with the game application. The response from the in-game survey will be analyzed via coding to provide insights about the end user expperiences of the Makahiki application.

We also plan to collect the logging data from all three sites to assess users' interaction with the system, as well as assessing the reliability and performance of the system.

The logging data will be analyzed to gather the following quantitative metrics:

- Popular Quests, Events, Activities, Commitments, RSVPs
- Referrals
- Daily logins, New Users
- Action Feedbacks
- Errors occurred
- Numbers of long latency responses

5.1.1.2 System Admin experience evaluation

We plan to perform structured interviews to the site administrators of the Hawaii Pacific University (HPU) and East-West Center at Hawaii (EWC) Challenges. There are two site admin-

istrators for each site: one whose main role is responsible for the system installation, deployment of the application, etc; another whose main role is responsible for the challenge administration, including setting up the users, game settings, prizes, etc. The two sites have different deployment strategies: HPU will deploy the Makahiki instance in its own infrastructure, while EWC will deploy the instance into the Heroku Platform as a Service (PaaS) environment. The two case studies will provide insight into the differences of site administrations between a traditional self-hosting environment and an cloud based PaaS hosting environment.

We will undertake three interviews for each site administrator: a. Pre-challenge interviews b. In-challenge interviews c. Post-challenge interviews The Pre-challenge interviews happen before the challenge. They evaluate how easy or difficult for a system administrator and challenge administrator to install, setup, configure a challenge tailored to their specific requirements. The In-challenge interviews happen during the challenge. They evaluate the required work for administrating the site during the challenge. The Post-challenge interviews happen after the challenge. They evaluate the overall experience of the site administration.

We will record the structured interviews and archive the email exchanges with the site administrators for correlated data analysis.

We will analyze both the quantitative and qualitative data collected from the interviews and email changes. The quantitative data include:

- time taken to install the Makahiki
- time taken to configure the Challenge
- number of problems encountered
- time taken in training
- time taken in administrating the challenge
- number of problems encountered during the administrating of the challenge
- cost of the self-hosting v.s. cloud-based infrastructure

The qualitative data include:

- What are the experiences of designing the game?
- What are the unique challenges for running their versions of Makahiki?

- What are the strenth of the administrative interface?
- What are the weekness of the administrative interface?
- How can we improve the administrative experience?

5.1.1.3 Game Designer experience evaluation

5.1.1.4 Game Manager experience evaluation

5.1.1.5 Researcher experience evaluation

Can Makahiki provide a mean to perform research on games for sustainability through real-time analytics?

5.1.1.6 Preliminary Results

We designed and implemented an energy challenge called the "Kukui Cup" for over 1,000 first year students living in the residence halls at the University of Hawaii in Fall, 2011. Response to this initial challenge was very positive. Over 400 students participated, for an adoption rate of approximately 40%. In the in-game survey of those participating students, over 90% of them said they would play the game if it were offered next year. 60% of participants said "ease of use" was the thing they liked best about the website. 40% responded "Nothing" when asked what was confusing about the website, and 32% responded "Nothing" when asked what they would change about the website.

The 2012 Kukui Cup is currently being held in the residence halls at the University of Hawaii, and additional Kukui Cup challenges are happening at Hawaii Pacific University and the East-West Center. We are in the process of collecting the data both from the challenge administrators and from the student players.

5.1.2 In-lab Makahiki Experiments

5.1.2.1 System admin experience evaluation

5.1.2.2 Game Designer experience evaluation

5.1.2.3 Developer experience evaluation

Can Makahiki provide an API and procedures to support enhancement with new features and capabilities with a minimum of impact on other aspects of the framework?

To evaluate question (2), we plan to perform the Development Enhancement Case Study research. It consists of one or several "case study" of external developers who are tasked with making an enhancement to the system. The goal for the developer evaluation is to find out: (a) What kinds of learnings must occur, (b) What kind of background is necessary from a developer to enhance the system, (c) What kinds of problems were encountered and how they were resolved, (d) What kinds of changes to the system could be made to address the problems.

We plan to collect and analyze the data from the followings:

1. *Log Book*: We will create a google Form for the developer to fill out at the end of each programming session. Figure 5.1 illustrates the google form used for Makahiki developer evaluation.

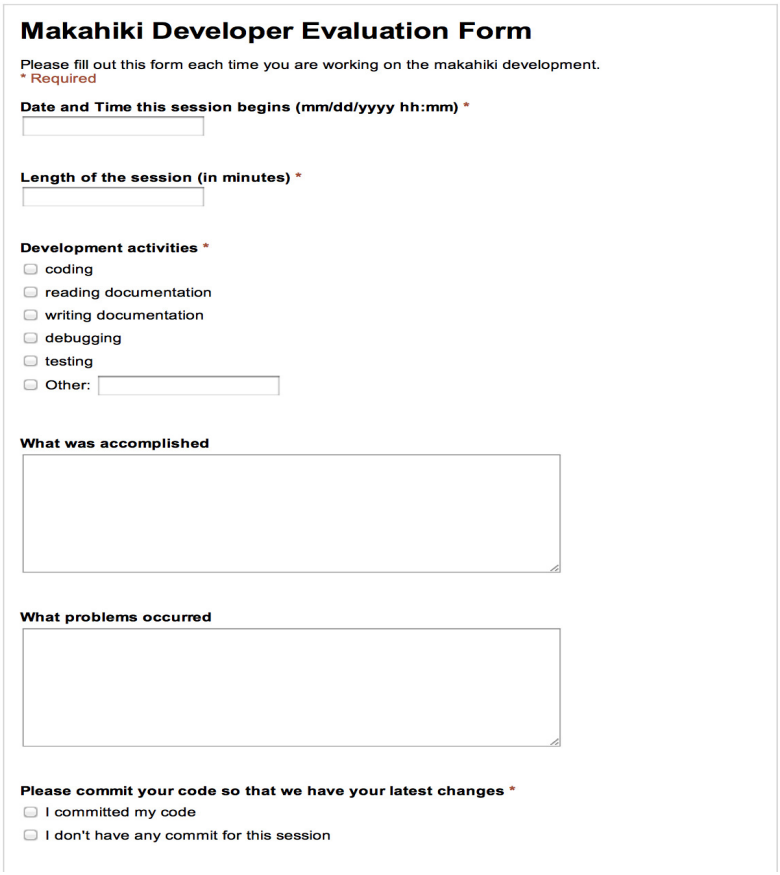


Figure 5.1. Makahiki Developer Evaluation Form

2. *Meetings* : We will have weekly developer meetings. we will record the meetings to support the analysis of development usability. we will focus on what kind of problems were encountered during the development.

3. *Emails and Chat sessions* : We will save the email exchanges with the developer and the online chat sessions for further analysis.

4. *Code Review* : We will review the development source code and documentation to identify the effectiveness of the enhancement and the impact to the whole application.

5.1.2.4 Preliminary Results

5.2 Lucid Design Dashboard evaluation case study

Chapter 6

Conclusion

This proposal laid out a research plan to investigate the information technology infrastructure that can support effective and efficient development of serious games for sustainability. The research includes the development of An innovative serious game framework for sustainability that combining education and behavior change, and an evaluation framework accessing the effectiveness and efficiency of the IT infrastructure for serious games for sustainability with regarding the most important stakeholder's perspective.

6.1 Anticipated Contributions

The anticipated contributions of this research are:

- developed Makahiki: open source information technology for development of serious games for sustainability.
- Evidence regarding the effectiveness and efficiency of Makahiki as a framework for development of serious games for sustainability.
- Evidence regarding the effectiveness and efficiency of second system as a framework for development of serious games for sustainability.
- Insights into the strengths and weaknesses of the evaluation framework.

6.2 Future Directions

There are a variety of directions that can be pursued once this research is complete, such as:

- Evaluate the other stakeholders experiences
- Build a community to expand content and game library
- Scale / expand to other geographical and cultural different locations. Moving beyond residence halls to other buildings on the UHM campus. Does a competition make sense for buildings where faculty and staff are the primary occupants? Outside the dorm, long-term financial incentives generated by returning a portion of financial savings to the departments that conserve energy might make more sense than prizes. Fostering energy conservation in homes through behavior change. With the growth of the smart grid, near-realtime power usage data will be available to more and more homes. While the direct feedback coupled with the incentive of lower utility bills is likely to lead to some energy conservation, web-based tools have the potential to help motivate behavior change on a large scale.

6.3 Timeline

The planned timeline for the research is given below:

- Fall 2011: Makahiki2 development start
- September 2012: HPU and EWC Kukuicup challenge
- September 2012: UH Kukuicup challenge began
- March 2013: evaluation of Makahiki using ICS691
- April 2013: UH Kukuicup challenge end
- Summer 2013: data analysis and dissertation writing begin
- October 2013: Followup studies of HPU and UH Kukuicup 2013 challenge
- May 2014: dissertation defense

Chapter 7

Qualitative Feedback Questions

This appendix lists the questions that assess stakeholders' experiences with the IT infrastructure for serious games for sustainability. The questions are separated into sections based on the stakeholder's role.

7.1 Player effectiveness

1. Do you find the game engaging to play?

Text field for answer.

2. What did you like **most** about the website?

Text field for answer.

3. What did you like **least** about the website?

Text field for answer.

4. Did you change you behavior during the game? if so, how?

Text field for answer.

7.2 Game Designer efficiency

5. Did you find it difficult to design the smartgrid game, or other games? if so, how?

Text field for answer.

6. What problem did you encounter in design and configuring the game?

   Text field for answer.

7. What do you like the least of the system?

   Text field for answer.

7.3 Game Manager efficiency

8. What problem did you encounter in managing the game?

   Text field for answer.

9. How often and what info do you look at the status page?

   Text field for answer.

10. Is it easy to approve the game action submissions?

    Text field for answer.

11. What do you like the least of the system?

    Text field for answer.

7.4 System admin efficiency

12. What problem did you encounter in installing and maintaining the system?

    Text field for answer.

13. What were your greatest challenges in setting up the system?

    Text field for answer.

14. Did you have to shutdown the system for maintenance? if so, for what reason, and for how long?

    Text field for answer.

15. What do you like the least of the system?

    Text field for answer.

7.5 Developer efficiency

16. How long did it take you to develop a new game / enhancement?

Text field for answer.

17. What is the most difficult part of learning the system?

Text field for answer.

18. What is the most difficult part of developing a new game?

Text field for answer.

19. What is the most difficult part of developing the enhancement to the system features?

Text field for answer.

20. what are the problems you encountered during env setup, develop, testing

Text field for answer.

7.6 Researcher efficiency

21. How long did it take you to collect the data for your research question?

Text field for answer.

22. What kind of analytics data you find most useful from system?

Text field for answer.

23. What problem did you encountered during your data collection?

Text field for answer.

24. What improvement do you suggest regarding the type of data or the way of collecting the data?

Text field for answer.

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