

**MAKAHIKI: A “SERIOUS GAME” ENGINE FOR SUSTAINABILITY**

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# **Abstract**

Energy education and conservation has become an international imperative due to the raising cost of energy and its irreversible environmental impact. My research seeks to investigate the approach of building a universal “serious game” engine to be easily adapted by different organizations to create engaging games to educate newer generations on renewable energy and energy conservation. The inaugurated resident hall energy competition at University of Hawaii in Fall 2011, “The Quest to Kukui Cup”, is the first deployment of the initial version of the Makahiki game engine. The initial deployment had shown encouraging results and potentials in the gamification approach to the energy education and conservation. This motivate a re-architecting of Makahiki to become universal “serious game” engine for sustainability that provides a production quality software system to be used in real world impact and a test bed for game related research in education and behaviour change in sustainability.

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# Chapter 1

## Introduction

The world is in the grip of an energy crisis. Fossil fuels (oil, natural gas, and coal) form the foundation of the world economy and their use is largely responsible for the industrialization and standard of living increases across the globe in the past century. However, the consumption of fossil fuels has led to a variety of problems that will have severe impacts on our environment and national economies.

There is no ‘silver bullet’ that will solve this energy crisis, it will require a series of changes in production, transmission, and consumption of energy taking place over decades. While we will need to switch to renewable energy sources, energy conservation is also an important strategy since a reduction in energy demand makes the transition to renewable sources easier. This research examines how to motivate people to conserve electricity by changing their behavior in the context of a university dormitory energy competition.

### 1.1 Energy Conservation

One way fossil fuel use can be decreased is by decreasing the total amount of energy consumed. Socolow and Pacala have proposed a plan for reducing global GHG emissions to acceptable levels through the implementation of a series of ‘wedges’, where each wedge represents a reduction of 25 billion tons of CO<sub>2</sub> emissions over 50 years [12]. One of the 15 wedges they proposed is to cut electricity use in homes, offices, and stores by 25%. On a local level, the state of Hawai‘i has created the Hawai‘i Clean Energy Initiative, which seeks to reduce Hawai‘i’s fossil fuel use by 70% by 2030 through increasing the use local energy sources (for electricity and transportation fuel) to 40% of demand and reducing demand by 30% through efficiency and conservation [8].

Amory Lovins coined the term *negawatt* to refer to power that has been conserved, and therefore, does not need to be generated [5]. Negawatts can be ‘generated’ in two basic ways: by

increasing the efficiency of devices that consume energy, and by changing people's behavior reduce energy use.

### **1.1.1 Energy Education**

### **1.1.2 Behavior Change**

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 [2]. Data from a military housing community on Oahu show energy usage for similar homes can differ by a factor of 4 [9].

One common way to attempt fostering behavior change is by providing information to the targeted population, often through mass media. While convenient, this approach often turns out to be ineffective [6]. Two strategies that have proven to be effective are providing direct feedback on energy usage [2], and a toolbox of techniques such as making public commitments and establishing social norms [6].

## **1.2 Research Description**

This research project seeks to (a) A production quality software system that can be easily used in real world to create engaging games for sustainability education and behavior change. (b) An experimental test bed for Gamification research into the effectiveness of different game mechanics in the context of sustainability

### **1.2.1 System**

The dorm energy competition will take place over 4 weeks in October 2010 in two freshman residence halls on the UHM campus. Power meters will be installed on each floor of each building and the power and energy data will be recorded every 10 to 15 seconds. Since each floor has its own meter, each floor will compete to have the lowest energy consumption during the competition.

A website is being built that will provide information about the competition to the participants. Participants will log into the website with their UH username and password, and each participant will see a personalized home page that displays data such as his or her floor's power usage in near-realtime, their floor's cumulative energy usage for the competition, and their floor's

ranking in the competition. The website has been designed to take into account the research in environmental psychology about how to foster behavior change.

The other major feature of the competition website is to make a variety of tasks available to the participants. The tasks are designed to either increase the *energy literacy* of the participant, or help reduce the energy consumption of the floor, or both. Energy literacy is composed of knowledge, positive attitudes, and behaviors related to energy. An example of energy knowledge would be the difference between a watt and a watt-hour, an example of a positive attitude would be “Americans should conserve more energy”, and a positive behavior would be turning off lights when leaving a room [3]. The tasks are divided into three different types: activities, commitments, and goals.

Associated with each task is a number of points, called Kukui Nut points. When a participant performs a task, such as determining the amount of power each device in their room consumes, they can submit information on the website demonstrating their completion of the task. In the case of the power audit, the information might be the list of devices in their room and the power consumption of each device. Once a website administrator verifies the information, the participant is awarded the points assigned to the completed task. These website tasks create a second parallel competition to see which participants can accumulate the most points.

A variety of prizes will be provided both for the energy conservation side of the competition, and the point competition. This prize structure provides an additional motivation for the residents to participate in the competition.

### 1.2.2 Research Goals

The research focuses on descriptive and exploratory statistics based around research questions. The research questions that will be investigated are:

- *To what extent was the website adopted by the participants?* Without significant adoption, it is hard to evaluate the other website-related questions.
- *How did energy use change during the competition?* This is the standard measure for an energy competition, with the expected result being energy conservation during the competition.
- *How did energy use change after the competition?* Understanding changes in energy use after the competition is over gives insight into whether changes during the competition were sustainable. Existing research focuses primarily on the competition itself, not examining the reasons why energy usage might rebound after the competition is over.

- *How effective were the tasks available via the website?* The tasks participants undertook can be tracked using website log data and compared to changes in their energy literacy.
- *How appropriate were the Kukui Nut values assigned to tasks?* The Kukui Nut points assigned to tasks are intended to motivate participants to perform the tasks, but the values were assigned without any participant data.
- *What is the relationship between energy literacy and energy usage?* The hypothesis is that more energy literate participants will conserve more energy.
- *How important was floor-level near-realtime feedback?* There are good reasons to believe that floor-level near-realtime feedback will lead to increased energy conservation, but they greatly increase the competition budget and logistical complexity. Is the trade-off worth it?

### 1.2.3 Evaluation

There are four primary sources of data available to examine the research questions:

- power and energy data from each floor,
- detailed event logs from participant actions on the website,
- participants' performance on an energy literacy survey to be administered before and after the competition,
- and a survey on the competition as a whole to be administered after the competition.

This rich dataset allows the examination of several relationships. The energy data alone provide insight into what effect (if any) the competition had on participants' energy usage, particularly to what degree energy use rebounds after the competition is over.

The combination of the website log data and the pre- and post-competition energy literacy scores sheds light on whether the tasks available on the website led to increased participant energy literacy, and if so, which tasks were most effective.

Finally, the combination of the energy usage data and the energy literacy scores allows look at the hypothesis that those floors that were more energy literate conserved more energy, both during and after the competition.

## 1.3 Outline

The proposal is organized into the following chapters:

- ?? looks at related research, including dorm energy competitions, energy feedback, and psychological techniques for fostering behavior change.
- **Chapter 3** describes the system we will be evaluating, which includes the dorm energy competition, and the associated website.
- ?? lists our research questions and explains our plan to evaluate them.
- **Chapter 5** concludes the proposal with a list of anticipated contributions and future directions.
- ?? covers the definitions of power and energy, and their interrelationship. Understanding these two concepts is critical to understanding the evaluation (and an important part of energy literacy).
- ?? lists the set of tasks to be made available to participants through the website to improve their energy literacy.
- ?? provides a Hawai‘i-specific survey designed to assess the energy literacy of participants.
- ?? contains questionnaire to be administered to participants after the competition has ended.

# Chapter 2

## Related Works

### 2.1 Defining Gamification

Although gamification is a popular word nowadays, there are quite a few definitions came from different fields. Marketing industry 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 seems evolve gamification with the goal of engagement. Some others considers any game related application is gamification, including 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. [?]. It consists of 4 components:

- 1. Game:** It is different than playful interaction, playful design.
- 2. Element:** It is not the complete game such as a serious game.
- 3. Non-game Context:** Similar to serious game, it uses game for other purposed than game's normal expected use for entertainment.
- 4. Design:** It is not game-based technologies or practices of wider game ecology.

Figure 2.1 illustrates the distinction with serious games and playful interaction.

### 2.2 Gamification Examples

There are many examples of application that effectively employs game design elements. We will only briefly discuss 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 example list here is solely personal selection with the hope to cover the broad range of influential gamification cases and in

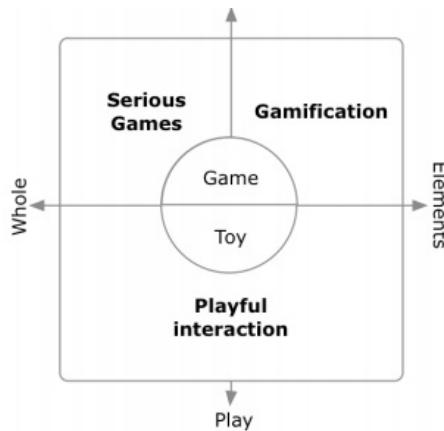


Figure 2.1. Defining Gamification

no way a completed list. In this quickly evolving landscape, it may well be a risk of missing some eminent ones.

### 2.2.1 FourSquare : Check-in to Unlock

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 and made badges rewarding a common practice in most of catch-up gamified applications. Foursquare proved that simple game mechanics can affect behavior that can engage 10 million customers and being a successful business model. By employing gamification elements such as points, badges, levels and leaderboards, it engages users to revisit a location such as restaurant or pub and become a loyal customer and finally the "major" 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.

### 2.2.2 Nike+: Making Fitness Fun

Nike+ [?] is a social running game-like service 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 fitness program: motivation. Nike+ makes it easy for runners to upload their run data to the website and start challenging themselves and their friends, they can also get supports from their friends.



Figure 2.2. Foursquare makes modern badges popular

**CHALLENGE YOURSELF AND OTHERS**

Together, Nike+ ran **440,870.111 mi**

17734 Laps around the world	17096 Trash-talking challenges	17089661 Pounds burned	8570 Stronger powersongs
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What's happening now in Nike+

Check out the most recent activity from runners in your country.

3.9 mi	3.86 mi	3.34 mi	3.39 mi	2.56 mi	2 mi	3.58 mi
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**How to Get Started**

Follow these simple steps to participate in Nike+ activities.

- 1. Get the Gear**  
Check out our product options and find the right gear that fits your running style.  
[PRODUCTS >](#)
- 2. Join Nike+**  
Set up an account and start saving your runs, setting goals, and challenging friends.  
[REGISTER >](#)
- 3. Sync Your First Run**  
Start saving your run history and watch yourself become a better runner over time.  
[LEARN MORE >](#)

Figure 2.3. Nike+ makes fitness run

### 2.2.3 Microsoft RibbonHero - Making You Better Your Job

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, which according to the belief that Office "has a lot of powerful features that users might not know but can be really useful". The game gave users a chance to game experience with software outside of typically dry IT training videos.

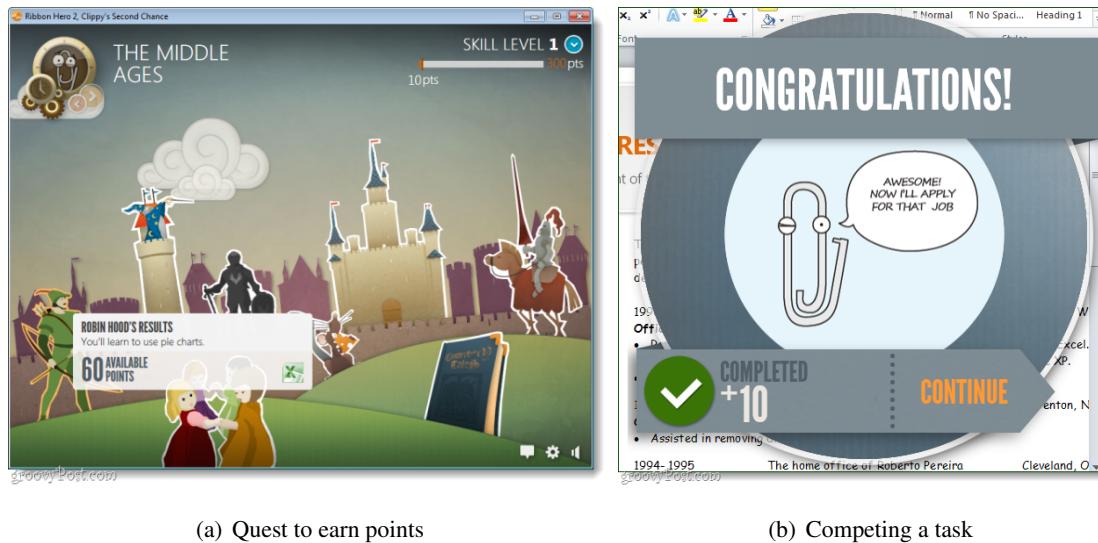


Figure 2.4. RibbonHero Helps to Learn Office

### 2.2.4 RecycleBank - Making the World Sustainable

RecycleBank [?] introduces a series of "Green Challenges" that used gaming techniques to motivate participants to learn about green living and to take small green actions to live more sustainable lives. 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.
- 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.



(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 2.5. RecycleBank - Gaming for Good

## 2.3 Gamification Related Concepts

### 2.3.1 Serious Game

A Serious game is a game designed for a primary purpose other than pure entertainment (Wikipedia). It includes categories such as educational games and advergames (advertising), political games, and training game (also known as game-learning).

One excellent 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.

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 victo-

rious example of gamification in science [?]. Sebastian Deterding's definition [?] 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.

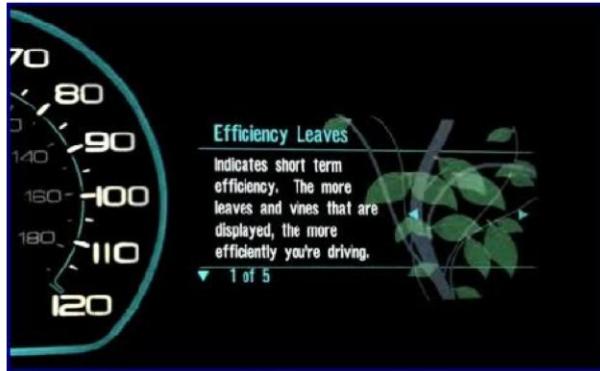
### 2.3.3 Gameful Interaction Design

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 (figure), 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 (figure). [?]. 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 or Escalator

Figure 2.6. 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 Why Games and Now

Gamification is not about games, in fact as a subject gamification is deals with everything else but games. But the research in gamification have to largely base on 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? Researchers published the results of a study in the May 1998 issue of Nature [] that 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. Even before, back in 2008, Gabe Zichermann coined the term "funware", which is the use of game mechanics in non-game contexts to encourage desired user actions and generate customer loyalty [wikipedia]. But now the term gamification replaces funware and climbs to the peak of the hype cycle within one year.

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, and gamification is a way to arrive at a "fundamental understanding of what it is that's pleasurable to people" from many aspects of life.

In his book "Total Engagement" [?], Stanford professor Byron Reeves describes a "Game Tsunami" is happening now, "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 thirty-five, and 26 percent of players are over fifty, an increase from 9 percent 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 twenty-five hours per week, compared with seven hours a week for all video games.

One the similar landscape, researcher and game designer Jane McGonigal also advocate playing game is the solution to the "Broken Reality" in her book[?]. 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. Thats 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."

The following sections examine a few popular games and genre to understand why game give games such power in our society.

#### **2.4.1 Ancient Board 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 exhibited in the British Museum (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 states the connection between play and education of both adult and children. He points out that, etymologically in Greek the terms "paideia," the word for education/culture, "paidia," the word for play/game/pastime/sport and "paides" the word for children, have the same root, and 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 for the free citizens in a society which honors philosophers.".

Another set of pieces belonging to a game exhibited are the label-shaped ivories, inscribed on one side with words, such as MALE (E)ST (means "bad luck"), NUGATOR ("trifler"), etc., and on the other with numbers. The whole series of numbers on these ivories runs from 1 to 25, and includes in addition 30 and 60; The highest numbers have inscriptions of a complimentary character, e.g., FELIX ("lucky") and BENIGNE ("kindly").[?] The pieces may have been used in the Roman game called "the game of soldiers". In the current day world, one can relate the worded and numbered ivory pieces to the badges in modern games.

An important game antique in the British 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 Iraq. [?].



Figure 2.7. The Beauty of Ancient Board Games

### 2.4.2 Angry Birds: the Additive Casual Game

In today's tech world, no gaming platform is completed without the new star game Angry Birds. This simple game has been downloaded over 300 million times, and has been played roughly 200 million minutes a day across the world, that is 1.2 billion hours a year. According to Nieman Journalism Lab [?], all person-hours spent creating and updating the entire wikipedia totals about 100 million hours. That is half day of the Angry Birds play time.

Why is this seemly simple game so massively additive? Charles Mauro discussed the cognitive ways of Angry Birds in Human factor engineering (aka usability engineering) for the sake of answering the more "important" real world question, "why users don't find their company's software or product engaging?": [?] (1) Simple Engaging Interaction Concept: Angry Birds' simple interaction model is easy to learn and incremental increase of complexity with anticipated rewards. (2) Cleverly managed response time: In Angry Birds design, it is not "faster is better", instead, different birds have different trajectory time and the flight path of the bird is intentionally illustrated. It solved one huge problem for user interfaces - error correction. It also take a seemly long time for the pigs to expire once their house are collapsed, this non-functional time delay increases the playfulness of the game and bring users entertainment.

Michael Chorost [?] explains that Angry Birds is addictive because: (1) its simple, with no learning curve to get going; (2) its rewarding we get a primitive pleasure in blowing stuff up; (3) its realistic the physics of the game are just as youd expect; and (4) its funny the sounds, laughter and backflips are amusing. The anticipation of reward puts your dopamine system into overdrive, which makes you compulsively want to know what will happen when you fling the next bird.

### **2.4.3 FarmVille: Social Games**

With the motto "Connecting the world through games", Zynga who found in 2007 quickly become the top game company catching up to the more traditional establishment such as EA and Activision Blizzard. With the help of social network platform Facebook, the FarmVille and CityVille quickly become the most popular games within Facebook. Zynga later expanded the games into other platform such as mobile and new google+ social network.

FarmVille has 71 million active players and although it is free to play, Zynga is estimated to generate \$50 million in revenue from the most engaged players who buy virtual goods in game. Phil Michaelson [?] writes about 8 tactics that FarmVille uses to design for Engagement:

1. Reward users for returning in a short time period.
2. Reward users for helping friends every day.
3. Allow users to create without typing.
4. Show progress everywhere on everything.
5. Make users feel lonely without friends because if they get friends on, theyll stay longer.
6. Enable self expression.
7. Offer increasing levels of complexity for mastery.
8. Have surprises and limited time events.

### **2.4.4 World of Warcraft : Alone together in MMORPG**

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, only topped by Wikipedia. On average each WoW-player spends 17-21 hours per week playing WoW.

From his research in MMORPG, Nick Yee, [?] describes 5 Motivation Factors for Why People Play them:

(1) Relationship: This factor measures the desire to develop meaningful relationships with other players in the game - usually in the form of a supportive friendship.

(2) Immersion: This factor measures the desire to become immersed in a make-believe construct. Players who score high on this factor enjoy being immersed in a fantasy world they can wander and explore.

(3) Grief: This factor measures the desire to objectify and use other players for one's own gains. Their means may be both outward or subtle by killing or deceiving.

(4) Achievement: This factor measures the desire to become powerful within the construct of a game. Players who score high on this factor try to reach the goals as defined by the game.

(5) Leadership: This factor measures the gregariousness and assertiveness of the player. Players who score high on this factor prefer to group rather than solo.

Most of the activities offered by a MMORPG are already present in single player games. What makes a difference for many is apparently the shared experience, the collaborative nature of most activities and, most importantly, the reward of being socialized into a community of gamers and acquiring a reputation within it. [?]. its the people that are addictive, not the game

Based on longitudinal data collected directly from playing the game, Nicolas Ducheneaut etc [?] concludes that

(1) WoW is not just communities, as most MMORGPs emphasize. In the basic, WoW truly is a virtual Skinner box [?], smoothly increasing reward and difficulty and reinforcing player commitment along the way. Players are always on the edge of opening up new abilities, of discovering new content.

(2) Many of WoWs subscribers play alone with a different kind of social factor, "audience", a sense of social presence. It is different than the quest grouping that providing direct support and camaraderie. There are three appeals in being "alone together" in multiplayer games: (a). interacting with an audience: MMORPGs are in essence reputation games - an avatar wearing powerful items, for instance, is essential to the construction of a players identity (b). Being surrounded by others. (c). Laughing at and with others.

## 2.5 Why Gamification ?

### 2.5.1 Game can change the world

In her popular and inspiring TED talk "Gaming can make a better world" [?] and 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 said "Reality is broken", and game is the fix. Games are nothing more than unnecessary obstacles that we volunteer to tackle. Why are we spending so much time on unnecessary obstacles? McGonigal says it has a lot to do with eustress, or positive stress. Based on the findings of positive psychology, She argues that the blissful productivity comes from the flourishing feeling, i.e., Positive Emotion, Relationships, Meaning and Accomplishments.

Another instrumental work came from Byron Reeves's book "Total Engagement", [?]. He argues that games, especially MMO type games and virtual worlds, can change the way people work and business 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.

### **2.5.2 A Game Layer On Top Of The World**

Seth Priebatsch, young CEO at startup SCVNGR, gave a great talk at TED titled The game layer on top of the world[?] . His main message is: Last decade was the decade of social. This next decade is the decade of games. social layer's purpose is to connect; a game layer is to influence.

How to build a game layer? He claims there are seven game mechanics that can get anyone to do anything, and lists four of them: 1) Appointment dynamic: in which to succeed, players have to do something at a predefined time, generally at a predefined place. 2) Influence and status: the ability of one player to modify the behavior of another's action through social pressure. 3) Progression dynamic: success is granularity displayed and measured through the process of completing itemized tasks 4) Communal discovery: a dynamic wherein an entire community is rallied to work together to achieve something, to solve a challenge. It leverages the network that is society to solve problems.

### **2.5.3 Game Based Marketing**

In his book "Game Based Marketing", Gabe Zichermann stated that "FunWare", aka, Gamification, is about taking the lessons learned from the games industry around points and badges and levels and challenges and achievements and bake those into any kind of life experience. Games

can help improve the outcomes in every aspect of life. 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 (FunWare) exploit 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.". This resonates the volunteering attribute of game play in McGonigal's book.

## 2.6 Science behind Gamification : Motivation and Behavior Change

Researchers from psychology, game industries and academia, have studied the psychology of motivation that makes online games so engaging. Online games are voluntary experiences that become so addictive that "people [who play them] won't even go to the bathroom [in the middle of a game]," Rigby pointed out.

### 2.6.1 Flow

Psychology professor Mihaly Csikszentmihalyi introduced a specific kind of happiness that he named "flow"[?], which is widely accepted to be one of the fundamental reasons that people play games. Flow, a state of absorption in one's work, is 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.

As Csikszentmihalyi describes, there are seven core components of flow that are summarized in Table 2.1. These components can be broken into two categories: conditions and characteristics. Conditions must be achieved before flow can be reached. Characteristics occur while a person is in flow, even though they may be unaware of it.

In order to achieve the flow, the right conditions above must exist. The last and the most 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 2.1 (based on a diagram from Csikszentmihalyi, 1990, p 74).

Table 2.1. Flow Condition and Characteristics

Conditions of Flow	Explanation
Clear tasks	Person understands what they must complete
Feedback	Person receives clear and immediate feedback showing what succeeds and what fails
Concentration/focus	Person is not distracted and can fully attend to the task
An attainable, balanced goal	Goal is challenging and within their abilities to complete
Characteristics of Flow	Explanation
Control	Person believes their actions have direct impact on tasks and that they can control the outcome
Diminished awareness of self	Complete focus on the task leaves little room for feeling self-conscious or doubt. Often described as becoming a part of the activity.
Altered sense of time	Perception of time is distorted. Seconds can feel like minutes, minutes like hours. Yet, time also passes by quickly, unnoticed.

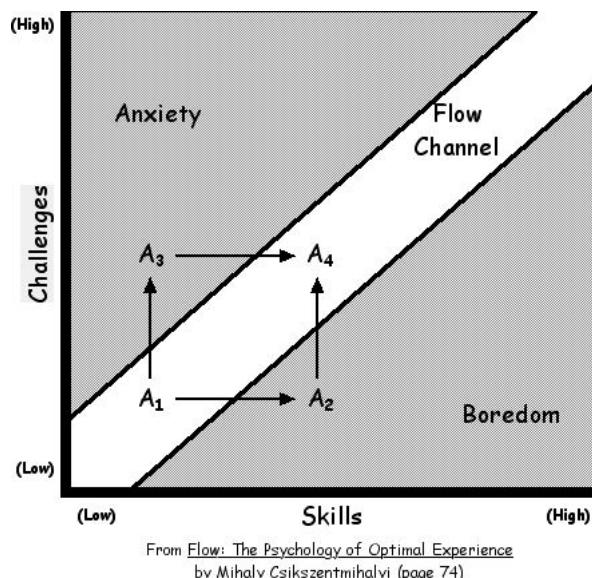


Figure 2.8. The state of flow is achieved between anxiety and boredom

## 2.6.2 Player Type

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

- \* Achievers are driven by in-game goals, usually some form of points gathering - whether experience points, levels, or money.
- \* Explorers are driven to find out as much as they can about the virtual construct - including mapping its geography and understanding the game mechanics.
- \* Socializers use the virtual construct to converse and role-play with their fellow gamers.
- \* 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. Amy Jo Kim applied the model in her gamification approach by overlaying social actions from the game on top of the player types.

## 2.6.3 Fogg Behavior Model in Persuasive Design

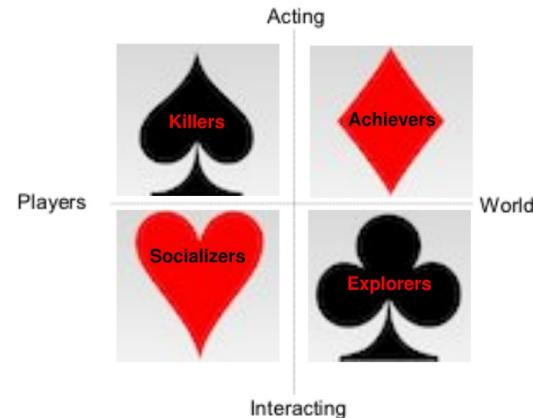
Stanford University's researcher BJ Fogg [?] introduces the Fogg Behavior Model (FBM) to explain what causes behavior change. The model shows that three elements, Motivation, Ability, and Trigger must converge at the same moment for a behavior to occur.

- 1.Motivation: the person wants desperately to perform the behavior (i.e. he is highly motivated)
- 2.Ability: the person can easily carry out the behavior (i.e. he considers the behavior very simple)
- 3.Trigger: the person is triggered to do the behavior (i.e. he is cued, reminded, asked, called to action, etc.)

Michael Wu uses FBM to analyze why and how gamification are able to drive actions. [?]. "Game mechanics and game dynamics are able to positively influence human behavior because they are designed to drive the players above the activation threshold (i.e. the upper right of the ability-motivation axis), and then trigger them into specific actions. In other words, successful gamification is all about making these three factors occur at the same time."

Wu describes a Fogg Behavioral Model and suggests that Gamification is an iterative process and works best when motivation, ability, and trigger (what they are told) all three of these con-

## Bartle's Player Types (1996)



(a) Bartle's Player Types

## Social Actions (2010)



(b) Kim's Social Actions for Players

Figure 2.9. Player Types

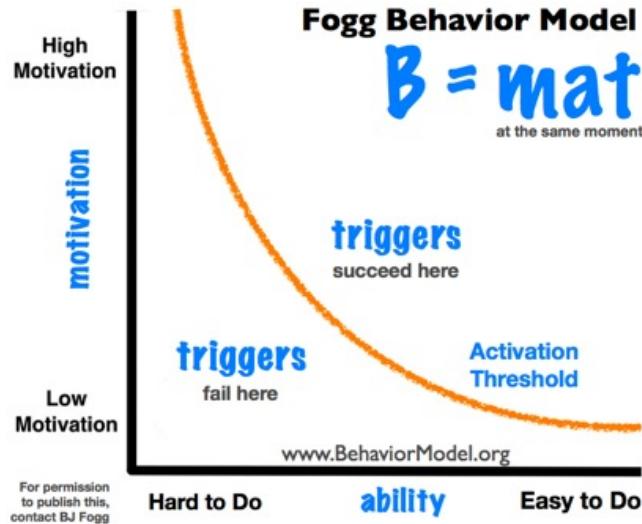


Figure 2.10. Fogg Behavior Model

verge. If a game you designed is not working, assess all three elements, figure out which elements need changes and improvements, and then, redesign the game in your feedback system accordingly to get the desired response.

#### 2.6.4 Persuasion Profiling

Researchers at Stanford, [?], for example, have begun to develop the technique of persuasion profiling. This technique builds a profile of which psychological triggers work best for a given person, and uses these triggers to drive new behaviors in the future. In other words, beyond focusing on what content someone might prefer, this approach determines the how to deliver it most effectively.

[?] Cialdinis six principles of persuasion [2][3] - six ways of framing a persuasive request to increase behavioral compliance : 1. Principle of reciprocity: People feel obligated to return a favor. 2. Principle of scarcity: When something is scarce, people will value it more. 3. Principle of authority: When a request is made by a legitimate authority, people are inclined to follow / believe the request. 4. Principle of commitment and consistency: People do as they told they would. 5. Principle of consensus: People do as other people do. 6. Principle of liking: We say yes to people we like.

## 2.7 Gamification Debates and Critiques

Debate continues over whether gamification itself is inherently good or bad. That is, is its use motivated by bad intentions to dupe people into doing things that aren't necessarily in their best interest? Or are some attempts at gamification merely poorly executed, so that its effects are superficial and fail to transform people's behavior in long-lasting, positive ways? "If gamification is fundamentally about tricking people to feel happier about situations that aren't going to be better [for them], then it's problematic on a lot of levels – both ethically and in effectiveness in the long term," according to Kevin Werbach, a Wharton professor of legal studies and business ethics who organized the conference with Dan Hunter, a professor at New York Law School. "The question is: What are the aspects of [gamification] that are really about meaningfully improving people's experience?"

After his inspiring talk in DICE2010, Jesse Schell and Bryan Reynolds (Zynga chief designer) discussed about "Gamification vs. Gameplay" in DICE 2011's opening session "Hot Topic". [?] . They are arguing in a very basic level of the definition of gamification. Brian considered "Gamification is where you use game elements to try to get people to do stuff they don't want to do", while Schell responded that "It's a problem solving situation that you enter into because you want to". Reynolds argued Everyone who has tried to use game mechanics to improve their marketing has only managed the most basic concepts, and Schell responded that this was the developers', not the concepts fault.

In a debate-style session of GDC 2011, "The Great Gamification Debate", [?] panelists argue the merits of bringing gameplay mechanics to just about everything. On the pro-gamification side was Jane McGonigal (Social Chocolate), Margaret Robertson (Hide & Seek), and Jesse Schell (Schell Games). On the other side of the table was Eric Marcoullier (OneTrueFan), Ross Smith (Microsoft), Ian Bogost (The Georgia Institute of Technology), and Margaret Wallace (Playmatics). Although they most agreed that definition of gamification was summed up best by 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 Jesse Schell believes the gamification is the cultural shift in every day life, Ian Bogost considers that the purpose of gamification is to cash in on the current popularity of games. While Margaret Wallace said "If a word gains traction, why fight it?", Bogost disagreed, saying that words actually do matter. Regarding the concept of intrinsic and extrinsic rewards through gamification, Schell notes the definition is "squirrely". While the idea of

gamification is reduced by some to merely behavioral conditioning or creating a kind of Skinner box for users, McGonigal maintained that users should at least find a reward of value.

As we see now, while the gamification is hailed as the next big thing in our future of life, there are a lot of criticism from academia and industry.

Designer Umair Haques post *Unlocking the Mayor Badge of Meaninglessness* [?] arguing "too much gamification is about zero sum games: often, for me to win, you've got to lose. For example, many "gamified" sites simply offer a fixed number of badges, trophies, or other trinkets, to the first N participants that, for example, visit six different pages. That's because, third, many games are relying on or worse, trying to create artificial scarcity."

Designer Stephen Andersons presentation *Long After the Thrill: Sustaining Passionate Users* [?] argues (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.

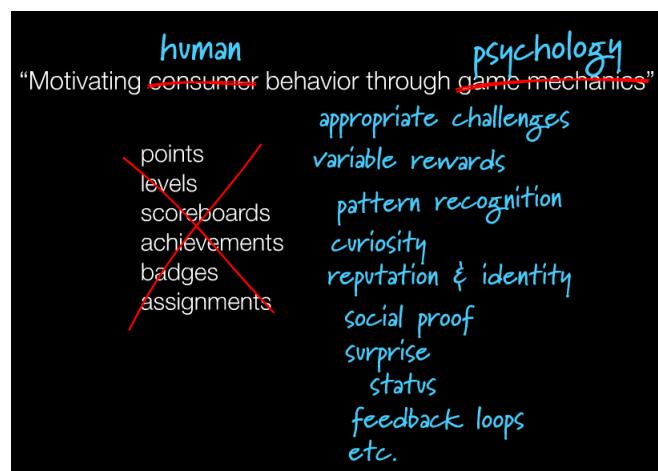


Figure 2.11. Gamification is about extrinsic rewards [?]

Jane McGonigal, talked in GDC 2011 that We dont need no stinking badges: How to reinvent reality without gamification, [?] argued gamification confuses intrinsic/extrinsic motivation and propose "Gameful Design" instead of gamification. She claims that "Gameful is player-oriented", which presumes 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.

Many critiques are surrounded with the suggestion that current gamification is shallow and superficial, as Ben Sawyer states, "is really gamification 1.0 (at best)." [?] Most gamification does not provide and thus does not reward with in-game strategy. There is no grand mystery to unravel, no in-game process to optimize, and so it really isn't a game. Instead what he sees as Gamification 2.0 is sort of something of a combination of alternate reality games and augmented reality.

The followings are a few more eminent critiques of gamification:

### **2.7.1 Gamification is Bull\*it**

At the Wharton conference, Georgia Institute of Technology professor and game designer Ian Bogost called gamification efforts "exploitation-ware" that is being "invented by consultants as a means to capture the wild, coveted beast that is video games and to domesticate it for use in the grey, hopeless wasteland of big business." 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 states 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".

### **2.7.2 Pointsification**

In her blog, [?], Game designer Margaret Robertson criticizes that "Gamification is an inadvertent con. It tricks people into believing that there's a simple way to imbue their thing with the psychological, emotional and social power of a great game". She states that Gamification is the wrong word for the right idea. The word for what's happening at the moment is Pointsification. 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, the rich cognitive, emotional and social drivers which game designer are intending to connect with.

Pointsification, in and of itself, is a perfectly valid and valuable concept which nonetheless needs to be implemented carefully with due concern for appropriateness and for unintended consequences; while the actual gamification, (in her definition,) namely the conversion of existing systems into functioning games, is also a valid and valuable process which carries its own concerns, in other words, games are good, points are good, but games  $\neq$  points.

### **2.7.3 Can you gamify a suicide hotline?**

Can you gamify everything? "No, you can not gamify game". According to Gabe Zichermann, the idea of baking game mechanics into everything you do is fun, but when asked how would you make a suicide hotline fun, he admitted that adding games to a suicide prevention seems distasteful at first, but he could add a game mechanics like a competitive environment in a call center setting.

### **2.7.4 Intrinsic Vs Extrinsic rewards**

There are many debates against the current efforts of gamification that focus on extrinsic motivators (such as points, badges and rewards) versus intrinsic motivators generated by an individual's internal will or desires. Nicole Lazzaro states that "In the long run, extrinsic rewards are not fun," , "The use of extrinsic motivation will decrease motivation to use your products and services once you remove that reward.... You have to keep upping the dose to have the same motivation and change in behavior over time." [?].

Vockell [?] also resonates that in education psychology, Extrinsic motivators may lead to merely short-range activity while actually reducing long-range interest in a topic, while in Intrinsic motivators, people are best motivated when they are working toward personally meaningful goals whose attainment requires activity at a continuously optimal (intermediate) level of difficulty.

But Carnegie Mellon's Schell cautioned against writing off extrinsic rewards without a deeper understanding of the psychology behind motivation. "We don't fully grasp the complex relationship between intrinsic and extrinsic rewards," he noted.[?]

Michael Wu argues that extrinsic rewards can jumpstart intrinsic motivation, [?]. "The key realization is that gamification doesn't have to work long term to create sustainable value. It just has to work long enough for some other processes to take over as the primary driver of value. Subsequently, gamification will become a secondary reinforcement system that facilitates the primary value drivers.".

### **2.7.5 Gabe Vs Sebastin**

A very interesting debate [?] has been going on regarding the principles of gamification, between Gabe Zichermann and Sebastian Deterding. It started with Sebastian's long review on Gabe's new book "Gamification by Design". Deterding claims the book misunderstands a number of pieces of crucial terminology, makes "half-knowledge" statements against established re-

search, especially the theory of intrinsic and extrinsic motivation, and generally encourages the use of gamification as a cheap marketing gimmick. He expressed his strong concern of Zichermann's misrepresentation of a growing industry will hurt the industry in multiple ways.

Gabe responded that his book is a "practical book for practical purposes, focused not on games at all, but Gamification as a unique and hybridized discipline. Whether or not academics believe the techniques in the book work, they are based on my experience with dozens of clients, interviews with hundreds of practitioners, and extensive review of the literature and case studies."

### **2.7.6 Pawned. Gamification and Its Discontents**

In his Playful 2010 talk "Pawned. Gamification and Its Discontents" [?], Sebastian Deterding criticized the current gamification's potential pitfalls, along with a series gamification talks, workshops. [?], [?].:

1. Foursquare has an engagement problem. He notes that although Foursquare accounts grows from 2 million to 8 million in 2011, the daily checkins per user dropped from 0.5 to 0.34.
2. current gamified applications are very much like tic-tac-toe or Fisher Price toys: The opportunities users have to interact with them, and the kinds of challenges and interesting things to find out and fiddle with in these systems are so limited that they quickly are exhausted.
3. when it comes to why games are fun leads, current gamification practices confuse intrinsic/extrinsic motivation to (a). mistaking points/feedback (= rewards) to be game design, rather than rules/goals (= challenges). (b). overlooking the side effects of extrinsic rewards and quantitative performance measuring.
4. gamification can be used for evil purposes, in an exploiting way.

## **2.8 Gamification Design: HOW**

### **2.8.1 Gamification 1.0**

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

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

(a) Game Mechanics and Elements Satisfies Human Needs (Bunchball)



(b) basic mechanics

Figure 2.12. Gamification 1.0

## **2.8.2 SCVNGR Game Mechanics Playdeck**

Seth Priebatsch states that "Back at SCVNGR, we like to joke that with seven game dynamics, you can get anyone to do anything" [?]. Beyond the seven, they actually have 47, illustrated in a playdeck style published by TechCrunch [?]. It works as a set of flash cards and the SCVNGR employees are instructed to memorize those and find places where these game dynamics exist in their applications. Most of the mechanics in the deck are listed in the Appendix of this review.

Subsequently, social interaction designer Adrian Chan posted a blog, "I just killed a social game mechanic", [?], comments on each of the decks 47 points and points out that the sociological factors that make social gaming is not listed in the deck and the confusion around game mechanics and game dynamics.

## **2.8.3 Four Keys to Fun**

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" and most of the popular games selected in the research create 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."

In her Game Developer Conference (GDC) 2011 talk [?], Nicole Lazzaro presented the applying of the four keys to fun framework to design better engagement in games, especially the MSO (Massively Social Online) games.

## **2.8.4 Gamification Design Frameworks**

Game Design Framework: Mechanics/Dynamics/Aesthetics(MDA), introduced by game designer Marc LeBlanc, describes three pillars of a good game: [?]

Mechanics: the various actions, behaviors and control mechanisms afforded to the player within a game context. They make up the functioning components of the game.

Dynamics: run-time behavior of inputs and outputs between player and game, They are the player's interactions with mechanics.

Aesthetics: The desirable emotional responses evoked by the game dynamics. They are how the game makes the player feel.

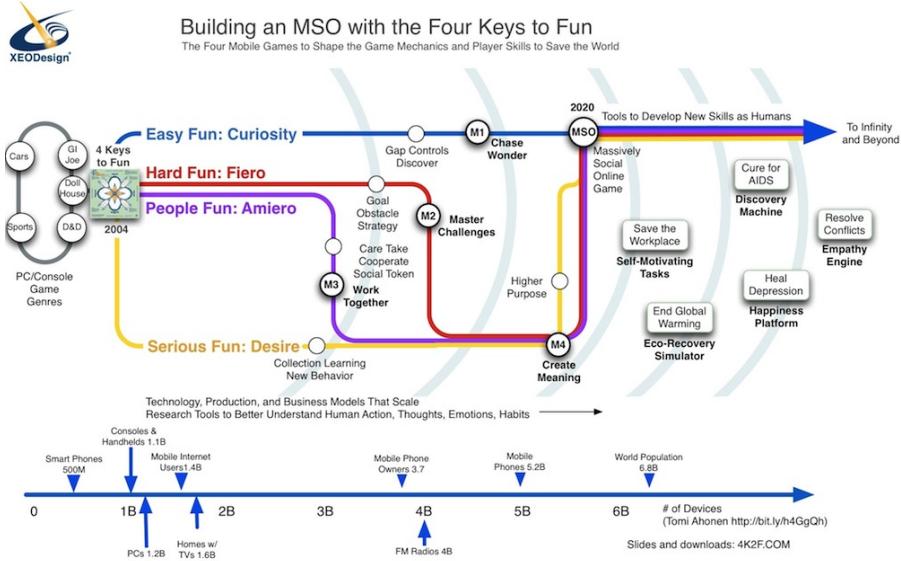


Figure 2.13. Four Keys to Fun Game Map

### 2.8.5 Smart Gamification (2.0?)

Amy Jo Kim presents Smart Gamification which focus on designing the effective Player Journey with intrinsic preferred over extrinsic reward. [?]. Kim points out that game techniques not equal to core experience and intrinsic value greater than extrinsic rewards. Kim states that "a good game take the player on a journey toward mastery". When overtime players experience from newbie and become regular and finally turns into enthusiast, they progress from novice to expert and last to master. When designing 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. Kim incorporates the MDA framework, using it to guide and motivate the player journey.

Similarly, researcher Sebastian Deterding not only criticized the current practice of simple gamification practices but stressed the important of meaningful play and proposed three user experience design: Meaning, Master and Autonomy.[?], an adaptation to the three elements to motivate people in Daniel Pink's book "Drive: The Surprising Truth About What Motivates Us". [?]: Autonomy, Mastery and Purpose. 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.

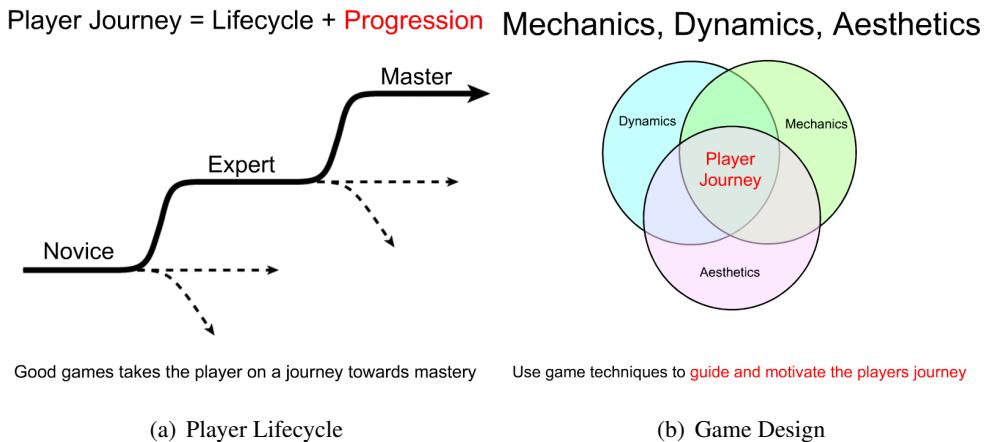


Figure 2.14. Designing Player Journey

## 2.9 Gamification Service and Platform

### **2.9.1 Commercial products and services**

This section outlines the current industry players that provides gamification service via platforms or consultation service. [see figure 2.1]. Almost all of them are recent startups that funded by venture capitals.

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 skinable 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 apps, 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 leaderboards. The javascript based "MiniBar" widget is a quick way to add game layer to the website.

Badgeville  
 Big Door Media  
 Bunchball  
 Cynergy  
 Gamify  
 SpectrumDNA  
 Reputely  
 Leapfrog Builders  
 iActionable  
 SCVNGR  
 Manumatix



Figure 2.15. Gamification Service Industry

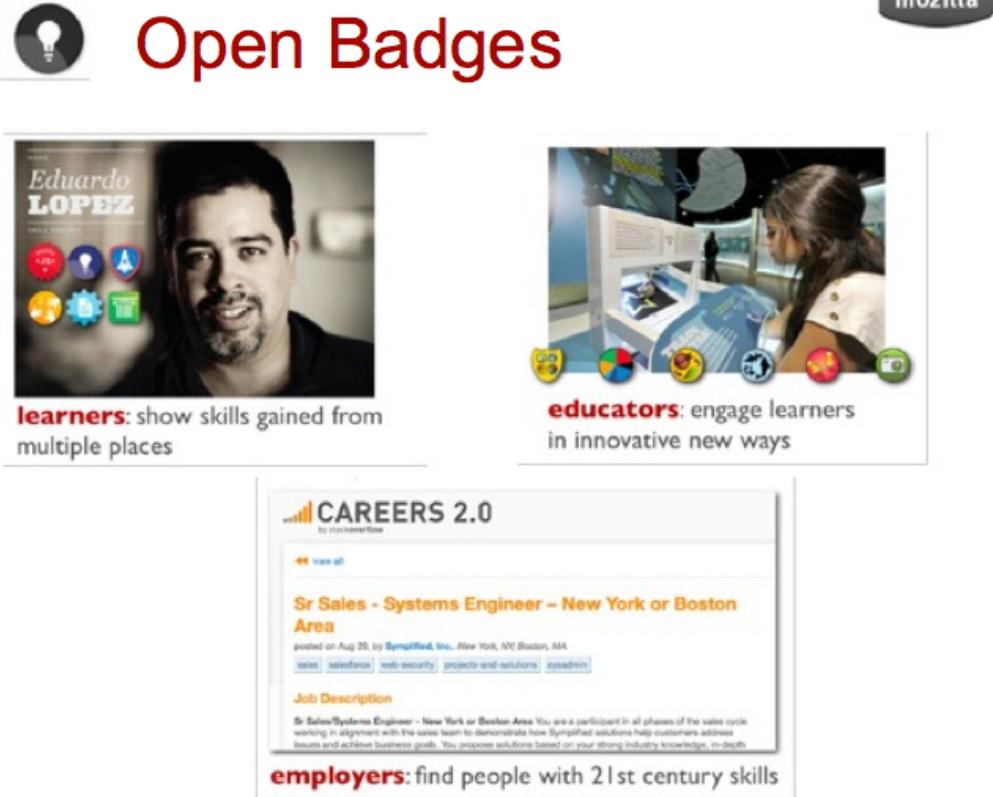
All of the above platforms feature built-in analytics built to provide some kinds of metrics about the result of the gamification. While Badgeville seems emphasize on social integration; Bunchball provides a comprehensive solution even with a game box; and BigDoor provides a simplest "MiniBar" for easy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

### 2.9.2 Mozilla - Open Badges Infrastructure

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 website, or being used in the job search as a convenient showcase of applicant's qualification.

### 2.9.3 Open Source Gamification Platform

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



The image shows the Mozilla Open Badges Infrastructure landing page. At the top left is a lightbulb icon. To its right is the title "Open Badges" in large red letters. In the top right corner is the Mozilla logo. Below the title, there are three sections: 1) A photo of a man with a beard, with several colorful skill badges overlaid on the left side. Below the photo is the text "learners: show skills gained from multiple places". 2) A photo of a young girl looking at a display board in what appears to be a science museum or exhibition. Below the photo is the text "educators: engage learners in innovative new ways". 3) A screenshot of a job listing on "CAREERS 2.0" for a "Sr Sales - Systems Engineer - New York or Boston Area". The listing includes a brief description and a link to "view all". Below the screenshot is the text "employers: find people with 21st century skills".

Figure 2.16. Mozilla - Open Badges Infrastructure

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

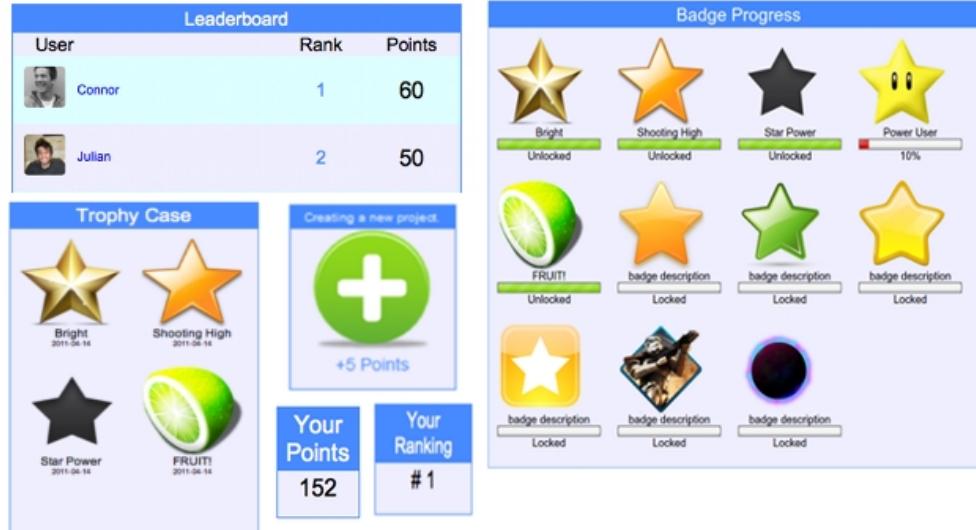


Figure 2.17. Open Source Gamification: Userinfuser Widget

## 2.10 Gamification Analytics

Ducheneaut and Yee etc [?] provides a good example of using game metrics for analysis of player's experience in a quantitative approach. They reported the relationship of playing time and leveling in the MMORGs, as shown in the following figure:

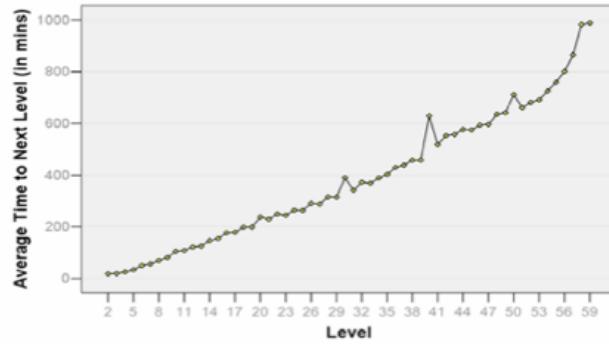
In the social game industry, player metrics collection and analysis are widely practiced to provide game designers to determine what the player audience likes and dislikes about a certain game experience. [?].

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

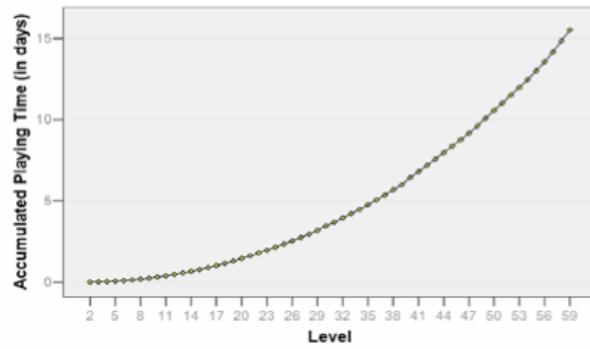
### 2.10.1 E-Score

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?



(a) Average time required to reach a level



(b) Average accumulated play time by level

Figure 2.18. Player Metrics

- \* 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?

### 2.10.2 Social Game Metrics

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

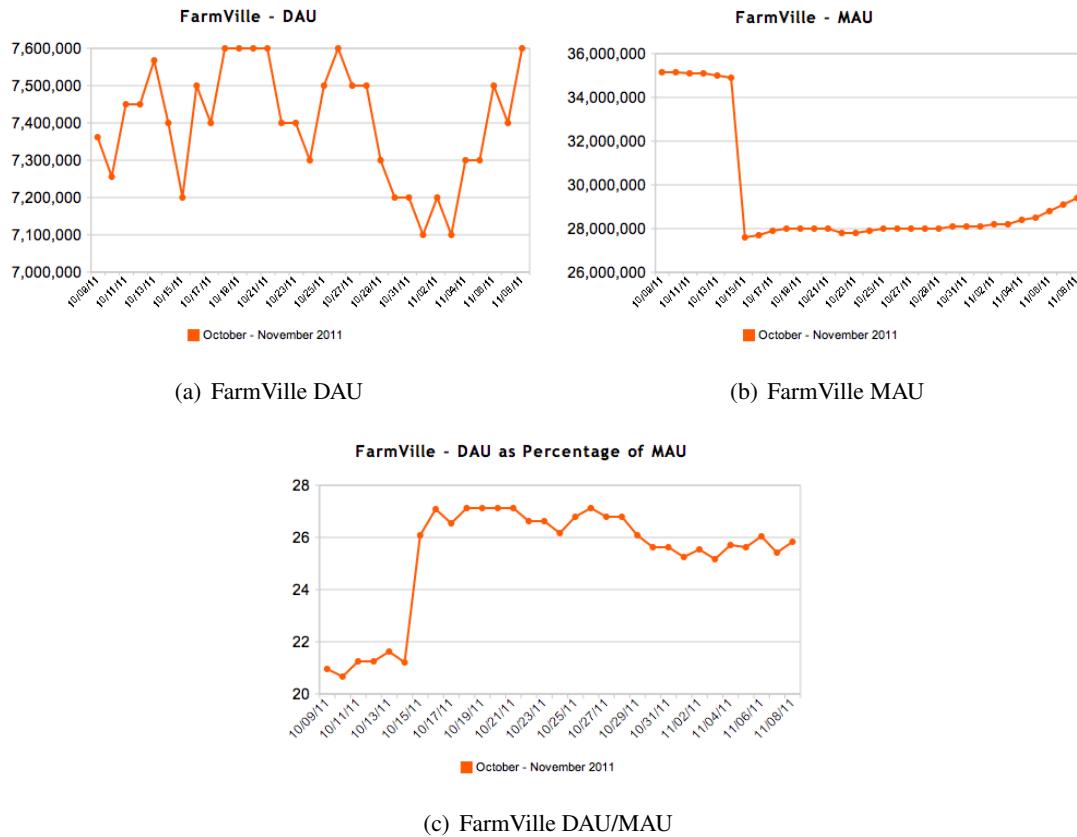


Figure 2.19. Social Game Metrics

Matt Fairchild lists and explains the basic terminology for social games metrics in his blog "The Secret Glossary of Social Games Analytics": [?]

**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 games 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 your average user engages with your game. The DAU/MAU ratio is strongly correlated with social gaming success. According to Lisa Marino from RockYou, the minimum threshold for DAU/MAU is .2, is necessary for a game to hit critical mass virality and engagement.

**Engagement:** Engagement measures how long they spend playing your 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 they enter the game. What do your 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 your product.  $K \text{ Factor} = (\text{Infection Rate}) * (\text{Conversion Rate})$ . 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, as marketers know, is when that infection results in a new sign up (or install.) 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 their entire lifetime on the network. For instance, is the user contributing to viral effects? Evangelizing the game? 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. According to Facebook app analytics provider Kontagent, a (very basic) equation is  $1/(1-k) * \text{Monthly ARPU} * \text{User Lifetime}$ .

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

**Re-Engagement:** Re-engagement is how you get them 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 your user base, as the opposite of churn.

**Viral Rate/Virality:** Measured by K Factor, the Viral Rate/Virality shows how much your users are promoting, evangelizing and spreading your game. social games are increasingly built around cooperation, competition and the constant addition of new features, which increase virality.

Out of the relatively thorough list of the metrics, user analytics platform Kontagent summarizes the top 10 social game metrics in their 2010 Social Game Summit presentation: [?]

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

# **Chapter 3**

## **System Design**

The system to be evaluated is a combination of an energy competition between residents of two freshman residence halls, and an associated competition website to be used by the residents participating in the event. The system has three goals:

- Enable research into fostering sustainable environmental behavior change
- Improve the energy literacy of the participants
- Reduce the energy consumption of the residence halls

The participants compete both to reduce energy consumption in the participating residence halls, and to accumulate points by performing tasks related to energy literacy and conservation through the competition website.

This chapter describes the components of the system, and ends with a discussion of the factors that pose a risk to the successful implementation and evaluation of the system.

### **3.1 Responsive UI Design**

We will examine the behavior of freshmen residents in student housing at the University of Hawai‘i at Mānoa in the context of a energy competition. An student housing energy competition typically involves residence halls attempting to reduce their energy consumption during the competition period by the greatest amount. The competition planned here is more complicated than standard competitions so that we can obtain data on a wider variety of behavior. The working name for the competition is the Kukui Cup. The kukui nut was burned by Native Hawaiians to provide light, making it an early form of energy in Hawai‘i.

## 3.2 Cloud-based Deployment

The core infrastructure required to enable an energy competition is electricity metering. In Hawai‘i, the vast majority of energy used in buildings is electricity, so measuring direct energy use reduces to measuring electricity use. While building-level metering is common for energy competitions, for this competition we plan to have floor-level metering of electricity. Metering at the floor level has several advantages:

- Finer-grained data about electricity usage
- Individual behavior changes more likely to be visible in data
- Makes the residents of a floor a natural ‘unit’ of competition

We also require that the meters provide sub-minute sampling times, preferably 10 to 15 seconds. This is an unusual requirement for meters used outside the home. We term this requirement *near-realtime* monitoring. As discussed in ??, providing near-realtime feedback on energy use is associated with greater reductions in energy consumption. Near-realtime feedback also enables participants to empirically determine how much electricity different devices consume, and become more aware of their energy use.

The other meter requirements are provision of an open API to allow retrieval of the data, and affordable pricing.

We have evaluated several building energy meters based on these criteria, and found 4 meters that meet all the criteria. All 4 meters support the Modbus/TCP protocol [7], which allows the meters to be queried over the Internet using a standardized protocol. Final selection of the meter will be done based on feedback from UHM facilities and the results of development of software to read data from the meters.

Installation of the meters involves placing current transformers over the incoming power lines in the electrical room on each floor. The current transformers convert current flowing over lines providing each phase into a small voltage which is then measured by the electrical meter. The electrical meters under consideration all have Ethernet ports, allowing them to be connected directly into the residence hall LAN. Once connected to the UHM network, they can be queried from any location.

The other infrastructure required is to place large TV display connected to an Internet-connected computer in the lobby of each building. This display will be used as a ‘billboard’ that

cycles through information about the competition, such as the floor standings and upcoming events (see ??). The Hale Aloha towers already have flat panel displays present in the lobby, which might be suitable for billboard display. Otherwise, two displays will need to be purchased. Some manufacturers make large format displays that embed a Windows PC in the display and are designed for this type of usage (such as the Samsung 460UXN-2, which costs approximately \$2,000).

### 3.3 Pluggable Game Components

Using the competition metrics, we can define various awards that can be won in the competition. In the event of ties, the winner will be resolved by random selection. Since the competition consists of 4 rounds, a common pattern is to have an award for each of rounds 1 through 3, and then an award for the entire competition (all 4 rounds). To incentivize participation, each award has an associated prize. We define the following awards for individuals. Note that all individual awards relate to KN since energy data only goes down to the floor level, not individual:

### 3.4 Configurable Game Instance

While the impetus for the website is to support the competition, it is also intended to provide information about the competition and residence hall energy consumption to the public (non-participants). Therefore, the website is conceived as a general portal into residence hall energy usage that will be available before and after the competition. During the competition period, the competition-specific portions of the website will be made available to participants. ?? shows a mockup of the front page of the website, where we can see overall residence hall energy consumption.

### 3.5 Energy Literacy Contents

Competition participants will be able to log into the website using their UH username and password, which will lead them to a personalized home page. The website will provide the following information to participants:

?? shows a mockup of the personalized home page for a participant named Maile. On the left hand side we see Maile's profile, showing her name, room number, and how many Kukui Nut points she has accumulated during the competition. The center column of the page relates to

the tasks that Maile can perform to gain Kukui Nut points (?? describes the task system in detail). The right hand side displays both power data and competition standings. The upper number is the near-realtime power usage for Maile’s floor, which is colored in red as an indicator that this value is above the pre-competition baseline. The lower number is the total electrical consumption for Maile’s floor in this round, which is colored in green since it is below the baseline and on target to meet the floor’s goal of a 10% reduction in energy usage for this round. The box in the lower right hand corner displays the competition standings that are most relevant to Maile.

# Chapter 4

## Experimental Design

This chapter describes the design of the experiment using the competition and associated website described in [Chapter 3](#). First we cover the different sources of data available for the experiment, followed by analyses performed on the data. The research questions we propose to investigate are:

- *To what extent was the website adopted by the participants?* Without significant adoption, it is hard to evaluate the other website-related questions.
- *How did energy use change during the competition?* This is the standard measure for an energy competition, with the expected result being energy conservation during the competition.
- *How did energy use change after the competition?* Understanding changes in energy use after the competition is over gives insight into whether changes during the competition were sustainable. Existing research focuses primarily on the competition itself, not examining the reasons why energy usage might rebound after the competition is over.
- *How effective were the tasks available via the website?* By using website log data, we can track what tasks participants undertook, and compare that to changes in their energy literacy.
- *How appropriate were the Kukui Nut values assigned to tasks?* The Kukui Nut points assigned to tasks are intended to motivate participants to perform the tasks, but the values were assigned without any participant data.
- *What is the relationship between energy literacy and energy usage?* We hypothesize that more energy literate participants will conserve more energy, so we examine the relationship both during the competition and afterwards.

- *How important was floor-level near-realtime feedback?* There are good reasons to believe that floor-level near-realtime feedback will lead to increased energy conservation, but they greatly increase the competition budget and logistical complexity. Is the trade-off worth it?

## 4.1 Administration

As the website is intended to be the hub for competition activity, it provides an contest administration interface where participants can be added, tasks created (see ??, and tasks verified (see ??). The contest administration interface is separate from lower-level administrative tasks such as the layout of the website, database table maintenance, etc. The contest administration will be performed by the researchers, and potentially trained volunteers ‘deputized’ to verify task completion, depending on the actual workload.

## 4.2 External cooperation

Unlike some ICS research, this project requires extensive cooperation with entities outside of the ICS department. Running the competition in student housing requires the enthusiastic cooperation of Student Housing Services, since the participants live in student housing and the meters need to be installed in the residence halls. We have met with Michael Kaptik, the director of Student Housing Services, and he appears eager to facilitate the competition (and of course Student Housing Services would benefit from any reductions in electricity use by residents). Installation of the meters themselves needs to be coordinated with Facilities, which handles electrical work on campus. We have met with David Hafner, Assistant Vice Chancellor for Campus Services who heads Facilities, and he is also very supportive of the competition plan and has indicated his willingness to facilitate the installation of the floor meters.

While the initial discussions with Student Housing and Facilities have all been positive, situations and personnel can change over time. There remains the risk that one of these entities might be unable or unwilling to cooperate, preventing the competition from taking place as planned.

If Student Housing were not supportive of holding the competition in the residence halls, it might be possible to switch to a competition between floors of some multi-story building on campus. However, this would significantly change the character of the research, and would require extensive redesign of both the competition and the website.

If Facilities was unwilling or unable to allow the installation of the floor meters in the residence halls, the research as planned could not take place. It might be possible to design an experiment that revolved solely around evaluating the effectiveness of increasing energy literacy using a redesigned website, but it would lack the critical component of evaluating the relationship between energy literacy and energy usage.

### **4.3 Participant engagement**

The installation of the meters to record floor-level electricity usage is the enabling component for the energy competition between floors and residence halls. However, energy literacy and near-realtime energy feedback rely on the competition website, and particularly on participant use of the website. The vast majority of entering freshmen own computers (Michael Kaptik stated that based on past surveys student housing resident computer ownership was something like 98%) and have used the Internet extensively. Thus there is little risk that the potential participants will not be able to use the website, but there is considerable risk that they will not bother to use the website due to lack of interest or conflicting demands on their time and attention.

We will attempt to limit this risk in several ways.

### **4.4 A-B testings**

The billboard is a non-interactive mode for the website designed to convey competition information to participants in the lobby of the residence halls in an ambient fashion. It is also expected that the billboards will remind the residents about the competition, making them more likely to participate. The billboard consists of a series of pages, which are cycled through after an appropriate delay (approximately 20 seconds). Billboard pages will display competition standings (individual, floor, and building), upcoming events, tasks recently performed by participants (in the style of the Facebook newsfeed), prize descriptions, and energy conservation tips. ?? shows a mockup of the billboard display.

large computer displays in the lobby of each residence hall that loop through interesting competition information, including current competition standings, upcoming events, and recent tasks performed by participants. We expect the billboard displays to provide a continuous reminder to residents about the competition and how they might participate. Third, we plan to have posters on each floor of the residence hall to remind residents about the competition and the website. Fourth,

participants will be notified about competition events via email and Facebook, with embedded links back to the website. Finally, the website makes it as easy as possible for participants to use the website by utilizing the University of Hawai‘i single-sign-on system, allowing participants to log on with their UH username and password, rather than a username and password specific to the website.

## 4.5 Real-time Game Analytics

There are two metrics for the competition: energy consumption (EC) score and Kukui Nut (KN) score. Energy consumption is the total amount of electrical energy consumed by a floor in kWh during a round as measured by the power meters. The energy consumption is normalized by subtracting the minimum floor power multiplied by the time interval in question (see ??). Therefore, floors are ranked in increasing order of energy consumption, with the floor with the lowest energy consumption being the winner. The floor-level energy consumption score can be aggregated spatially to obtain a score for an entire building, and also temporally to obtain a score for the entire competition across all rounds.

The parallel metric for the competition is Kukui Nut points. Kukui Nut points are assigned to individual participants for performing certain tasks via the competition website. The verification of task completion and recording of the Kukui Nut points are done entirely through the website, see ?? for more details. Kukui Nut points can be aggregated spatially to obtain a point total for an entire floor or for an entire building, and also temporally to obtain a score for the entire competition across all rounds.

# **Chapter 5**

## **Conclusion**

This proposal laid out a research plan to investigate the sustainability of energy conservation in a dorm energy competition using a competition website that integrates techniques from environmental psychology in an attempt to improve participants' energy literacy. The competition will employ floor-level near-realtime power meters to allow competition between floors, and make participants more aware of their energy usage. The competition website creates a parallel competition for Kukui Nut points through completion and verification of tasks intended to increase energy literacy. To examine the relationship between energy literacy and the website, and the relationship between energy literacy and energy conservation, an energy literacy survey has been developed and will be administered to the participants.

### **5.1 Anticipated Contributions**

The anticipated contributions of this research are:

- An increased understanding of the energy use of residence halls after an energy competition ends.
- Insight into the effect of energy literacy on energy conservation in a University residence hall context.
- Experience in designing a website intended to foster behavior changes related to energy use, and detailed data about participants' use of the website.
- An increase in energy literacy among the participants of the competition.
- A permanent metering infrastructure in two residence halls that will permit future competitions and research on those competitions.

- Institutional knowledge and logistical infrastructure for performing future competitions.
- A reduction in energy use (and therefore cost savings to Student Housing) for the two residence halls in the competition.

## 5.2 Future Directions

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

- Repeating the energy competition in future years (possibly in more buildings if funding is available), using insights gained from this research. Freshmen are a renewable resource, so the competition can be run once a year with new participants. Professor Johnson already plans to run future competitions, and has submitted an NSF grant proposal to that end. If the data indicates some subset of the website tasks are particularly useful, future competitions could switch to a treatment-based design to investigate those effects more robustly.
- 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.

## 5.3 Timeline

The planned timeline for the research is given below. Note that if the competition should be delayed due to one of the factors in ??, the competition might take place in February 2011 rather than October 2010. Even in this scenario, we believe it is possible to complete the dissertation by the end of the Spring semester in May 2011.

- Spring 2010: competition design, website design, buy-in from stakeholders

- Summer 2010: install meters in dorms
- September 2010: competition website complete
- October 2010: competition takes place
- November 2010: data analysis and dissertation writing begin in earnest
- February 2011: followup study takes place
- May 2011: dissertation defense

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