

MAKAHIKI: A “SERIOUS GAME” ENGINE FOR SUSTAINABILITY

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Abstract

Sustainability education has become an international imperative due to the rising cost of energy, increasing scarcity of natural resource and irresponsible environmental practices. Games have been shown to have great potentials in provide engaging interfaces for various serious contexts. My research seeks to investigate how to build a customizable serious game engine for sustainability called Makahiki. This work is motivated by the encouraging results of the inaugural residence hall energy competition at the University of Hawaii in Fall 2011. Makahiki is intended to provide a production quality, pluggable component-based open source game engine and an experimental test bed for game-related research in the context of sustainability education and conservation.

Table of Contents

Abstract	ii
List of Tables	v
List of Figures	vi
1 Introduction	1
2 Related Works	2
2.1 Gamification	2
2.1.1 Defining Gamification	2
2.1.2 Gamification Examples	2
2.1.2.1 FourSquare : Check-in to Unlock	3
2.1.2.2 Nike+: Making Fitness Fun	3
2.1.2.3 Microsoft RibbonHero - Making You Better Your Job	4
2.1.3 Why Games and Now	4
2.1.4 Why Gamification	7
2.1.5 Science behind Gamification: Motivation and Behavior Change	8
2.1.5.1 Flow	8
2.1.5.2 Player Type	9
2.1.5.3 Fogg Behavior Model	10
2.1.6 Gamification Debates and Criticism	11
2.1.6.1 Gamification is Bullshit	12
2.1.6.2 Gamification vs. Poinstification	12
2.1.6.3 Intrinsic vs. Extrinsic Motivation	13
2.1.7 Gamification Design	13
2.1.7.1 Gamification 1.0 : Game Mechanics	13
2.1.7.2 Four Keys to Fun	14
2.1.7.3 Smart Gamification	20
2.1.8 Gamification Services and Platforms	21
2.1.8.1 Commercial products and services	21
2.1.8.2 Mozilla - Open Badges Infrastructure	22
2.1.8.3 Open Source Gamification Platform	22
2.1.8.4 Summary of Gamification Platforms	23
2.2 Serious Games and Related Concepts	24
2.2.1 Serious Game	25
2.2.2 Persuasive Game	25
2.2.3 Gameful Interaction Design	26
2.2.4 Alternative Reality Games	26

2.3	Sustainability Education and Conservation	27
2.3.1	Energy Competition	27
2.3.2	Power House - A Energy Game	28
2.3.3	RecycleBank - Making the World Sustainable	29
2.4	Game Analytics	30
2.4.1	E-Score	30
2.4.2	Social Game Metrics	31
2.4.3	A/B Testing	33
	Bibliography	34

List of Tables

<u>Table</u>	<u>Page</u>
2.1 List of Game Mechanics (source: gamification.org [26])	15
2.2 List of Game Mechanics (cont.)	16
2.3 List of Game Mechanics (cont.)	17
2.4 List of Game Mechanics (cont.)	18
2.5 List of Game Elements (source: gamification.org [26])	19
2.6 Summary of Gamification Platforms	24

List of Figures

<u>Figure</u>	<u>Page</u>
2.1 Foursquare makes modern badges popular	3
2.2 Nike+ makes fitness run	4
2.3 RibbonHero Helps to Learn Office	5
2.4 The Beauty of Ancient Board Games in British Museum	7
2.5 The state of flow is achieved between anxiety and boredom (source: Czikszentmihalyi [16])	9
2.6 Player Types	10
2.7 Fogg Behavior Model (source: Lithium [73])	11
2.8 Gamification is about extrinsic rewards (source: Anderson [3])	12
2.9 Gamification 1.0	14
2.10 Four Keys to Fun Game Map (source: Lazzaro [41])	20
2.11 Designing Player Journey (source: Kim [35])	21
2.12 Gamification Service Industry	21
2.13 Mozilla - Open Badges Infrastructure	23
2.14 Open Source Gamification: Userinfuser Widget	23
2.15 Serious Game and Gamification (source: Deterding [19])	24
2.16 Examples of Gameful Interaction Design	26
2.17 Building Dashboard (source: Lucid [43])	28
2.18 Power House (source: Reeves [59])	28
2.19 RecycleBank - Gaming for Good	29
2.20 Player Metrics (source: Ducheneaut [21])	30
2.21 Social Game Metrics (source: Appdata.com [4])	32

Chapter 1

Introduction

Chapter 2

Related Works

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

2.1 Gamification

2.1.1 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” [13]. Wikipedia defines gamification as “the use of game play thinking and mechanics to solve problems and engage audiences” [68]. 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” [19]. This is the definition we choose to use in our discussion.

2.1.2 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.

2.1.2.1 Foursquare : Check-in to Unlock

Foursquare [25] 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. Foursquare proved that simple game mechanics can affect user behavior by engaging 10 million customers with a successful business model.



Figure 2.1. Foursquare makes modern badges popular

2.1.2.2 Nike+: Making Fitness Fun

Nike+ [49] 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 2.2. Nike+ makes fitness run

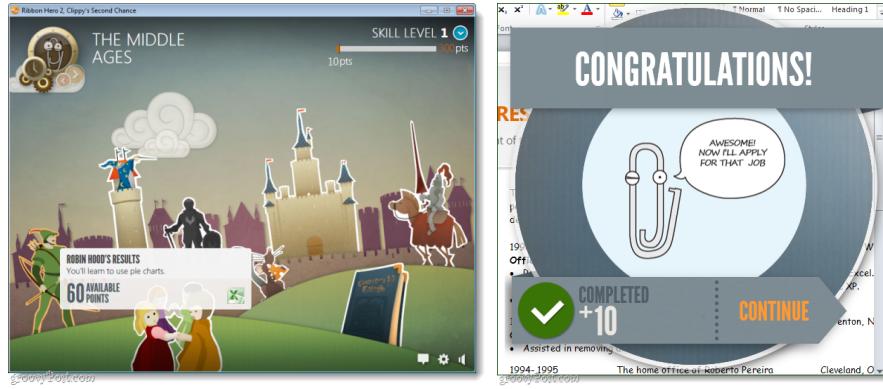
2.1.2.3 Microsoft RibbonHero - Making You Better Your Job

RibbonHero [60] 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.

2.1.3 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 [36] 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.



(a) Quest to earn points

(b) Competing a task

Figure 2.3. RibbonHero Helps to Learn Office

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 [67]. 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" [58]. 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” [39].

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”) [65]. 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. [69].

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.



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

Figure 2.4. The Beauty of Ancient Board Games in British Museum

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 [76]: (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” [77]. He claimed that “WoW truly is a virtual Skinner box”, smoothly increasing reward and difficulty and reinforcing player commitment along the way [75].

2.1.4 Why Gamification

In her popular and inspiring TED talk “Gaming can make a better world” [46] and in her book “Reality is Broken” [45], 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. 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” 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” [58]. 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” [78], 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”.

2.1.5 Science behind Gamification: Motivation and Behavior Change

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

2.1.5.1 Flow

Psychology professor Mihaly Czikszentmihalyi introduced a specific kind of happiness that he named “flow” [16], which is considered as one of the fundamental reasons that people play games [48]. 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.

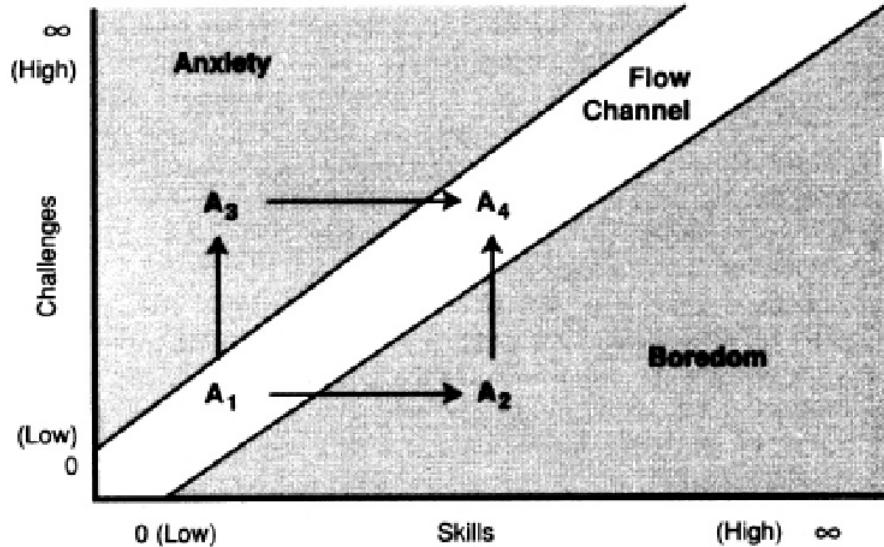


Figure 2.5. The state of flow is achieved between anxiety and boredom (source: Czikszentmihalyi [16])

2.1.5.2 Player Type

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 [6]. 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 [20]. Amy Jo Kim applied the model in her gamification approach by overlaying social actions from the game on top of the player types [35], as shown in Figure 2.8.

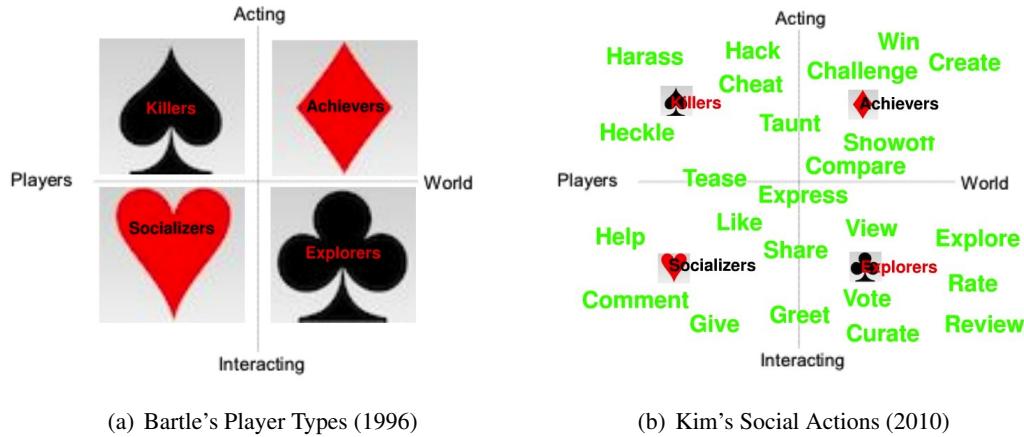


Figure 2.6. Player Types

2.1.5.3 Fogg Behavior Model

Stanford University researcher BJ Fogg introduces the Fogg Behavior Model (FBM) to explain what causes behavior change [24]. 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 [73]. “Game mechanics and game dynamics are able to positively influence human behavior because they 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 [33].

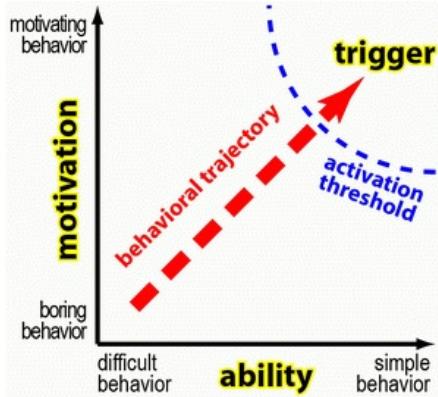


Figure 2.7. Fogg Behavior Model (source: Lithium [73])

2.1.6 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 [44]. 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 [30]. 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 [3]: (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 is not pure entertainment must go beyond delight/entertainment and be first & foremost useful. His idea is illustrated in Figure 2.8.

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 stink-



Figure 2.8. Gamification is about extrinsic rewards (source: Anderson [3])

ing badges: How to reinvent reality without gamification” [47]. 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:

2.1.6.1 Gamification is Bullshit

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” [11]. 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” [44].

2.1.6.2 Gamification vs. Poinstification

In her blog, game designer Margaret Robertson stated that current gamification is the wrong word for the right idea. “Whats happening at the moment is Pointsification” [61]. She criticized that the current use of gamification is a bad thing because its 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”.

2.1.6.3 Intrinsic vs. Extrinsic Motivation

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 [41]. 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 [64].

Michael Wu argues that extrinsic rewards can jumpstart intrinsic motivation [74]. 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.

2.1.7 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.

2.1.7.1 Gamification 1.0 : Game Mechanics

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 [18]. 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 [56]. Techcrunch published a “secret” game dynamics play deck that is used by Priebatsch’s company SCVNNGR [9]. The play deck is a set of 47 flash cards. Each card illustrates one game dynamics. SCVNNGR 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 socio-logical factors in social gaming and confuses game mechanics with game dynamics [14].

	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 [17])

Figure 2.9. Gamification 1.0

Gamification.org compiles a list of game mechanics and categories them into three types (Behavioral, Feedback, Progression) and their benefits [26]. Table 2.1 - 2.4 organizes the mechanics in type, a short description or examples, benefits, and possible player types in Bartle's model [6]:

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:

2.1.7.2 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" [40]. 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 [41]. Figure 2.10 illustrates the framework in more details.

Table 2.1. List of Game Mechanics (source: gamification.org [26])

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, usually 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, Socializers, 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, Achievers, Killers

Table 2.5. List of Game Elements (source: gamification.org [26])

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 higher 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.

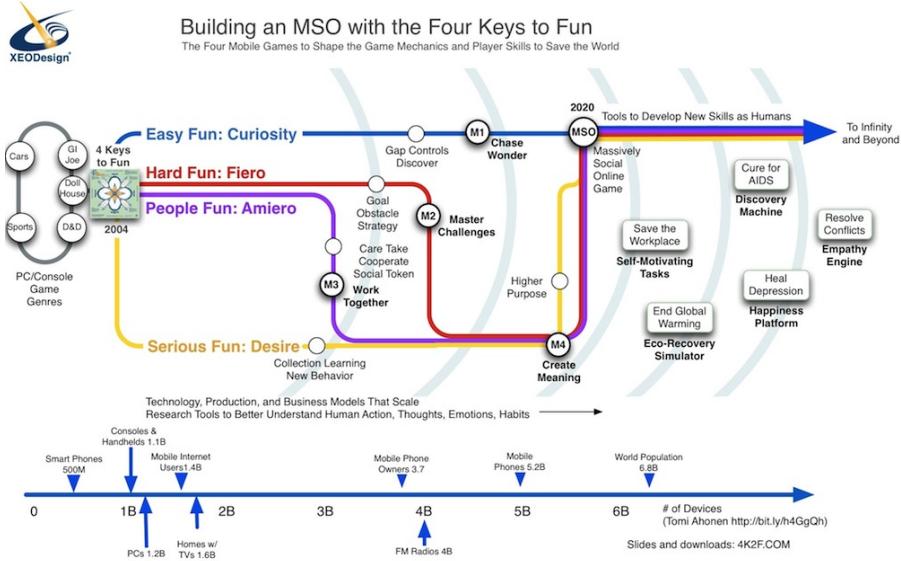


Figure 2.10. Four Keys to Fun Game Map (source: Lazzaro [41])

2.1.7.3 Smart Gamification

Amy Jo Kim presented “Smart Gamification” which focuses on designing the effective “Player Journey” with intrinsic reward preferred over extrinsic reward [35]. 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 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. As shown in Figure 2.11 (b), Kim incorporates the MDA framework [31], 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 a user experience design around the three most important aspects: Meaning, Master and Autonomy [17]. It is an adaptation to the three elements to motivate people in Daniel Pink’s book ”Drive: The Surprising Truth About What Motivates Us” [55]. 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.

Player Journey = Lifecycle + Progression Mechanics, Dynamics, Aesthetics

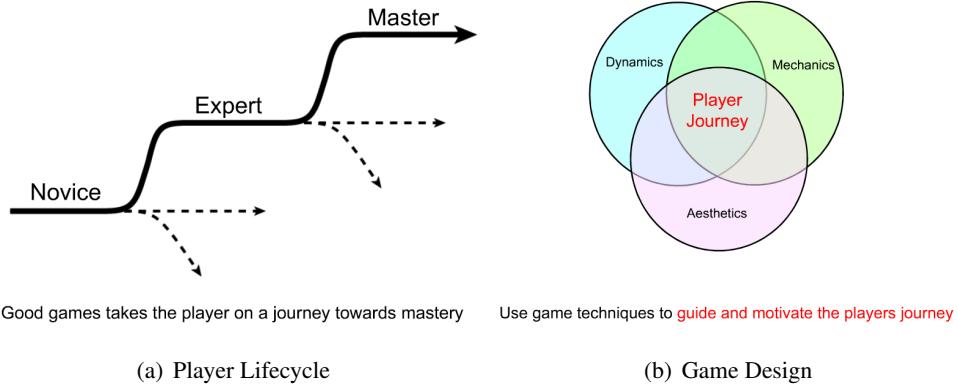


Figure 2.11. Designing Player Journey (source: Kim [35])

2.1.8 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.

2.1.8.1 Commercial products and services

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 2.12. Gamification Service Industry

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

Badgeville [5] 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 [13] 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 [8] 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.

2.1.8.2 Mozilla - Open Badges Infrastructure

Open Badges [51] 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.

2.1.8.3 Open Source Gamification Platform

Userinfuser [63] is an open source platform that provides customizable gamification elements designed to increase user interaction on web sites. The project involves badging, points,

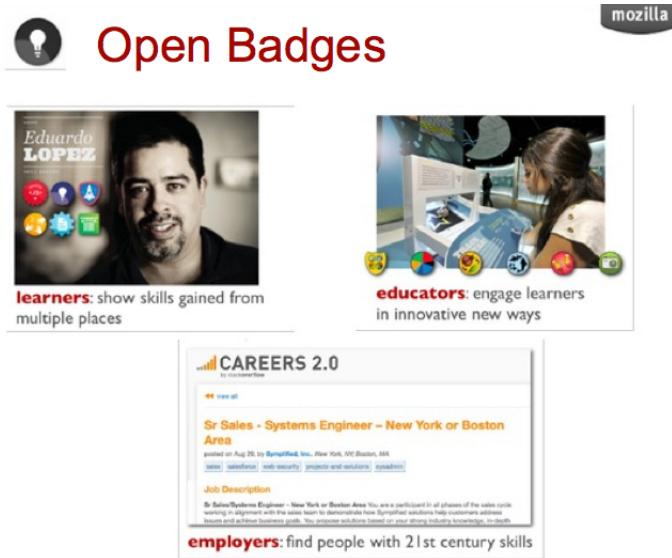


Figure 2.13. Mozilla - Open Badges Infrastructure

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 2.14. Open Source Gamification: Userinfuser Widget

2.1.8.4 Summary of Gamification Platforms

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

2.2 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 [19].

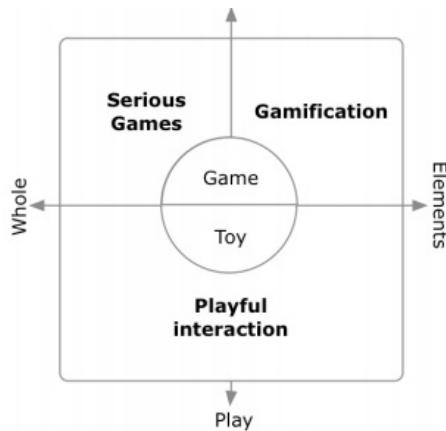


Figure 2.15. Serious Game and Gamification (source: Deterding [19])

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 for other purposes 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 discuss serious games and related concepts in more details.

2.2.1 Serious Game

A Serious game is a complete game designed for a primary purpose other than pure entertainment [70]. It includes categories such as educational games and advergames (advertising), political games, and training game (also known as game-learning).

One example is Fold.it, which made the headline [34] 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 victorious example of gamification in science [12]. Sebastian Deterding's definition [19] 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.

2.2.2 Persuasive Game

The term "Persuasive game" is introduced in the title book "Persuasive Games, The Expressive Power of Video games" by Ian Bogost [10]. 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 [24].

Loren Baxter [7] 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.

2.2.3 Gameful Interaction Design

According to The Interaction Design Association (IxDA) [72], 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. [50].

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 [32]. 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 [62]. 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.

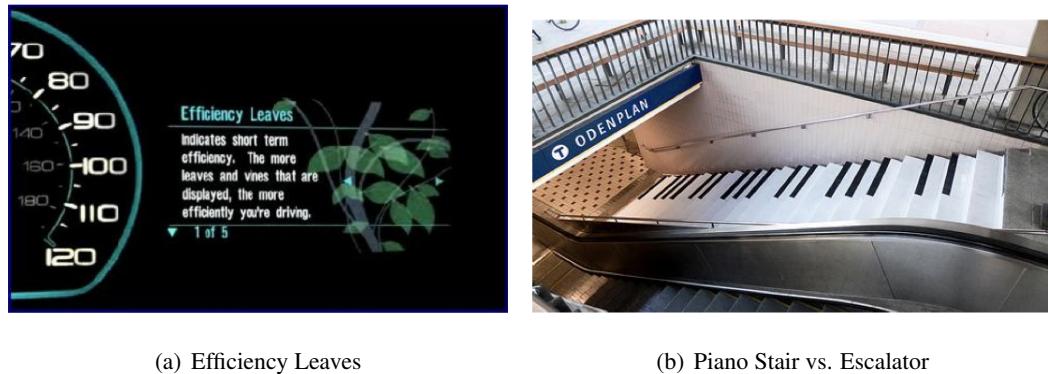


Figure 2.16. Examples of Gameful Interaction Design

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.

2.2.4 Alternative Reality Games

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" [22] and later "Evoke" [71] 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 [15]. 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 [66]. 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.

2.3 Sustainability Education and Conservation

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

2.3.1 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 [53]. 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 [43], 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 [42]. 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.



Figure 2.17. Building Dashboard (source: Lucid [43])

2.3.2 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 [59]. 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.



Figure 2.18. Power House (source: Reeves [59])

2.3.3 RecycleBank - Making the World Sustainable

RecycleBank [57] 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 [29], 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 2.19. RecycleBank - Gaming for Good

2.4 Game Analytics

Ducheneaut et al. provides a good example of using game metrics for analysis of player's experience in a quantitative approach [21]. They reported the relationship of playing time and leveling in the MMORGs, as shown in Figure 2.18:

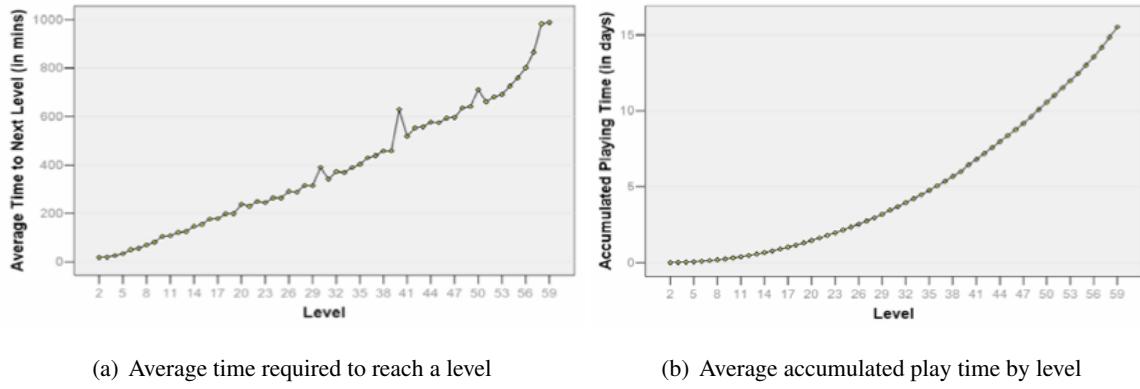


Figure 2.20. Player Metrics (source: Ducheneaut [21])

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 [52].

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

2.4.1 E-Score

E-Score is introduced by Gabe Zichermann, mainly applies in marketing gamification [54]. 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?

2.4.2 Social Game Metrics

Matt Fairchild lists and explains the basic terminology for social games metrics [23]:

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 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. $K \text{ Factor} = (\text{Infection Rate}) * (\text{Conversion Rate})$. 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 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, evange-

lizing 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 [4]:

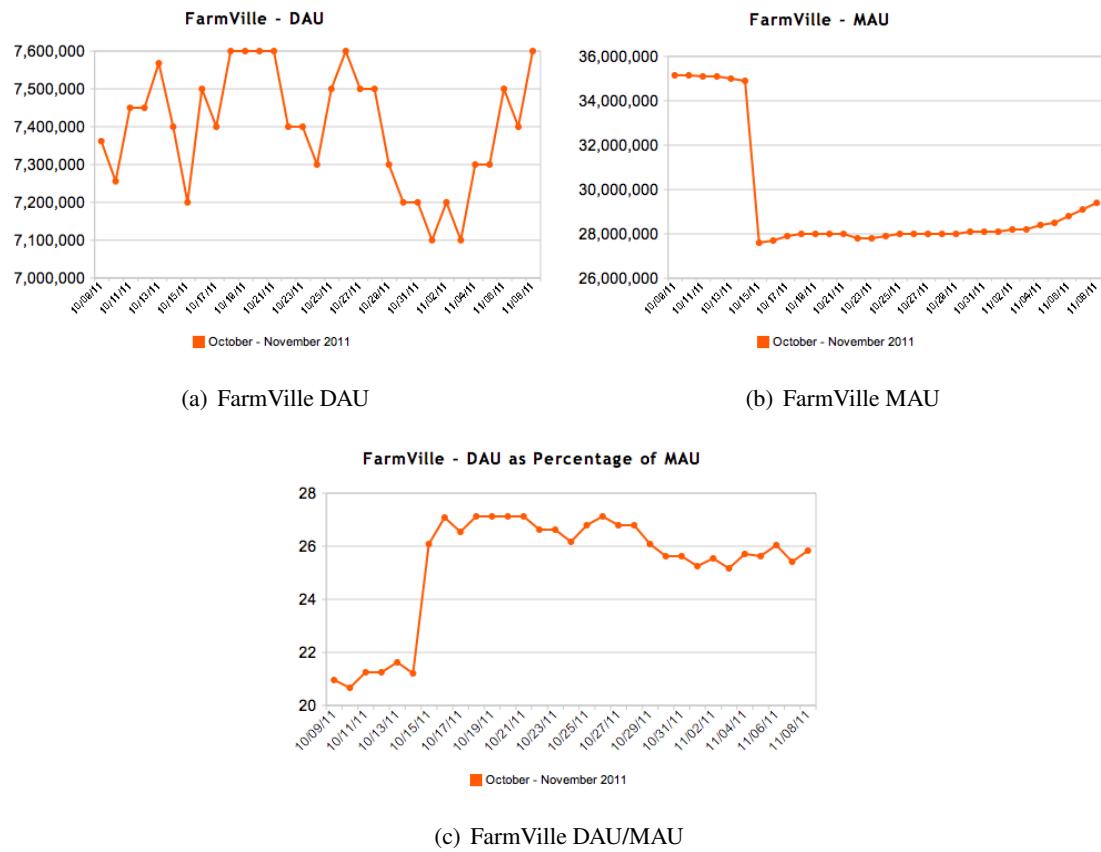


Figure 2.21. Social Game Metrics (source: Appdata.com [4])

Kontagent, a user analytics service company, introduces the top 10 social game metrics [38]: (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.

2.4.3 A/B Testing

A/B testing is often part of the services from analytics solution providers. For example, Google's Website Optimizer [27] 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 [37]. In A/B testing, two conditions are randomly presented to users in the same population and see how they respond. 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 [28].

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 [1]. 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% [2].

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