

AUTOMATA THEORY: A GAMIFICATION APPROACH

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ABSTRACT

Automata Theory, a theoretical branch of computer science, helps “to understand how machines compute functions and solve problems. An automaton is any machine that uses a specific, repeatable process to convert information into different forms. Gamification is an example of an automaton. The goal of gamification is the implementation of game mechanics in real-world contexts for non-gaming purposes, to foster human motivation and performance in regard to a given activity. This can be used for the automation” of mundane tasks. Customization and tailoring of interests, “content curation, life management, using all of these options, information can be gathered quickly and delivered effectively to” users. Based on this, a theoretical understanding of automata theory in gamification application was presented. The game mechanics configuration, when deliberately varied, in regards to the effect of fulfilling their basic functionalities can potentially improve user engagement, productivity, flow, learning, crowdsourcing, recruitment and evaluation, exercise, traffic violation, and so on.

Keywords: *Gamification, Game Mechanics, Automata Theory, Automaton, Automation, Social Networking*

1. INTRODUCTION

Automata Theory, a theoretical branch of computer science, was established during the 20th Century. This was brought about “as mathematicians began developing theoretical and literal machines, which imitate certain human abilities, complete calculations more quickly and reliably. The word automaton signifies automatic processes implementing the execution of specific processes. In other words, automata theory is the logic of computation with respect to simple machines, referred to as automata.” Consequently, computer scientists are able to understand how machines compute functions, solve problems, and the means to define functions as quantifiable or question as decidable [1]. “The goal of automata theory is to develop methods via which computer scientists can define and analyze the dynamic behavior of discrete systems, in which signals are sampled periodically.

The behavior of these discrete systems is determined by the way that the system is constructed from storage and combinational elements.

Automata theory provides an enabling environment for the designing and implementing games; with a lot of computer software designs using its principles. In recent research, game design based on automata theory supports programmer in implementing complex games and solving complex problems with ease. The use of games for educational and learning purpose has become modern trend, with students learning to gain the objectives and challenges in each stage. The students also learn how to apply these skills in their daily life in a responsive manner. Games play important role in behavior management as an interactive way to memorize new concepts [2]. In general, it has been observed that the designing of game is different from implementation of game, so without game design it

is very difficult for programmers to understand the working of the games. Automata theory plays an important role in bridging the gap between designing and implementation.

In recent time, there has been a wide spread of non-ludic applications leveraging game elements to engage people and motivate them. This phenomenon is characterized by the merging of recreational and serious activities. And also, by merging game and educational goals for the purpose of simulation or training. Gamification can be seen in such trends and has widely affected the design of interactive systems [3]. Gamification was introduced in Nick Pelling [4] in 2002, but gain popularity in 2010. With the likes of Microsoft, SAP, Deloitte using gamification techniques in various applications [5]. Even with the various definitions of the term gamification, it is generally recognized that gamification represents the implementation of game design mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems, in non-game contexts [6]. In this era of growing digital literacy, learning styles, and attitude to learning; informative paradigms and trends in education are required, to fulfill students' requirements, needs, and preferences. Gamification is a trend aiming to maintain an active learning to keep students engaged and motivated during their learning process [7]. Other areas where gamification has been applied are marketing, knowledge management, politics, health [8], road safety [9] and so on.

Gamification utilizes game mechanics and game design elements to measure, influence and reward target user behaviors. It takes the essence of the game-like elements such as – goals, rules, playfulness, elements of fun, feedback, reward and promotions - applies them to solve the real-world business problem. When applied in non-gaming context, these game mechanics work as a catalyst for making technology more engaging by influencing user behavior and social interaction methods [10]. Over time, gamification has been used successfully to achieve improvements in a multitude of tasks. For examples include enhancing learning by achievement badges [11], improving employee engagement [12] and encouraging users to act more securely [13].

1.1 Rationale for Applying Gamification

In the context of social media and advertising platforms, a lack of engagement and loyalty among the user base and increased user

dissatisfaction with the platform at large, can lead to churn. Especially for companies that rely on advertising revenue, the lack of a consistent, engaged audience could jeopardize key business models and monetization strategies [14]. Now, organizations have shifted their focus to user retention, find it a more efficient process because they are marketing to users who already have expressed an interest in the products and are engaged with the brand, making it easier to capitalize on their experiences with the company. Studies show increasing user retention by 5% can result in an increase in profits of 25% – 95%, and the likelihood of converting an existing user into a repeat user is 60% – 70%. To put that into perspective, the probability of converting a new lead is 5% – 20%, at best [15].

The advent of Web 2.0, propagated the shift of power from businesses to users. User engagement is not a new concept; however, companies often have difficulties retaining their users, and focuses on the acquisition of new users, which is time consuming and expensive [16]. User engagement is a key concept in the design of online applications, motivated by the observation that successful applications are not just used, but are engaged with. Users invest time, attention, and emotion in their use of technology, and seek to satisfy pragmatic and hedonic needs [17]. Engaging users to the point where they are moved to behavioral change do so by creating opportunities for emotional connections through ongoing consistently positive experiences. When users are engaged with an organization, they are emotionally connected, passionate about its products and services, as well as aligned with the purpose and direction of the organization. With greater access to information, more sensitivity to price, and less sensitivity to advertising, today's users are harder to win (acquisition) and keep (retention). The key to acquiring and retaining users in this environment is to engage them — to participate in an ongoing, two-way conversation with users [18].

1.2 User Engagement

User engagement (UE) refers to the engagement of users with one another, with a company or a brand. The initiative for engagement can be either user- or company-led and medium of engagement can be on- or off-line. User engagement is the emotional connection or attachment that a user develops during the repeated and ongoing interactions. Engagement accumulates through satisfaction, loyalty, influence, and excitement about

a brand. Services who engage users to the point where they are moved to behavioral change do so by creating opportunities for emotional connections through ongoing consistently positive experiences. When users are engaged with an organization, they are emotionally connected, passionate about its products and services, as well as aligned with the purpose and direction of the organization. With greater access to information, more sensitivity to price, and less sensitivity to advertising, today's users are harder to win and keep. The key to acquiring and retaining users in this environment is to engage them — to participate in an ongoing, two-way conversation with users [18].

1.3 Justification of the Study

The use of Gamification is on the increase due to its wide acceptance in various industries. Thus, it is noteworthy to take a look at the underlining principles governing how gamification works. And how the game design mechanics work individually or together to achieve the aim of gamification; which is gearing toward effective user engagement.

1.4 Significance of the Study

1. This study would affirm the goal of gamification.
2. This study would help to improve the understanding of gamification in user engagement strategy.
3. The study would also open new market to the private and public sectors.

2. LITERATURE REVIEW

The literatures reviewed highlights the various ways in which gamification has been employed to improve various aspects of living. Previous research, although not entirely conclusive, generally supports the hypothesis underlying the aim of gamification. However, previous studies have often treated gamification as a generic construct, neglecting the fact that there are many different game design elements which can result in very diverse applications and user experience.

As a precursor to the development of a game-like learning system, [19] carried out a survey on 51 undergraduate IT students to obtain their perceptions on game elements, which are the building blocks of what makes a game identifiable as such. All game elements that were presented to the respondents were highly rated. It was found that undergraduate students have a positive perception of

systems that use game elements and are interested in its use for learning. [20] addressed the development of the gamification concept with business applications; by survey of customers and managers seeking to participate in gamification on their websites. This supported a design theory outlining four key characteristics (Progress Paths; Feedback and Reward; Social Connection; and Attractiveness) in gamification platforms that attract consumers toward an enterprise's website.

Yigal & Meirav [21] examined the effects of points on performance in a computerized assessment of mastery and fluency of basic mathematics concepts. [22] tested students across two courses, measuring their motivation, social comparison, effort, satisfaction, learner empowerment, and academic performance. One course received a gamified curriculum, featuring a leaderboard and badges, whereas the other course received the same curriculum without the gamified elements. [23] aimed to evaluate the effectiveness of gamification platforms as a strategy for the engagement of students. Two badging platforms - ClassDojo and ClassBadges - was chosen. The main objectives were to generate involvement among individual and particular situations, increasing the interest, engagement and efficiency while performing a specific task.

Eric, Shawn, & Caroline [24] discussed the concept of gamification, based on a literature review and preliminary feedback from teachers using Classcraft, a role-playing game supported by a digital platform and a mobile application that were developed to answer high school teachers' classroom management needs. Based on a self-determination theory framework, [25] presented the results of a randomized controlled study that used an online simulation environment. And deliberately varied different configurations of game design elements, and analyzed them in regard to their effect on the fulfilment of basic psychological needs. [7] carried out an exploratory study, investigating the relation between motivation and engagement of the students and gamification in training. A survey was conducted to assess how students' behavior and motivation is affected by introducing a single, specific gamification element during a semester learning process. To stimulate competition among students, a ranking type plugin was introduced within the university learning management system used for extramural education.

Wee [26] considered the application of gamification in the context of aquariums and the tourism field and the non-technology-related antecedents to the use of gamification. The purpose is to consider issues related to gamification through the non-game aquarium context. [27] investigated how changes in cycling encouragement program game mechanics affect measured bicycle riding frequency. And compare effects for users both engaged via smartphone applications and across sub-samples determined by the participants' reported riding activity at program sign-up. [28] investigated how different goal foci (outcome and focus), goals orientation (mastery, proving, and avoiding), and goal attributes (specificity and difficulty) are associated with perceived importance of gamification, social networking and quantified-self features.

Johan, Poja, & Erik [29] investigates the effect of gamification on in-store mobile advertisement. More specifically, it investigates the effect of gamification on the inclination to act on offers gained at point of purchase. [30] presented a study examining the effect of gamification - building on leaderboards - on Learning Performance. [31] explored the construct validity of a new gamified assessment method in employee selection, developed resulting from the situational judgement test (SJT) methodology. [32] presented the implementation of a gamified application for helping students learn important facts about their study program. This focuses on two design features: The first feature is feedback, which is expected to increase engagement, with personalized ("tailored") feedback being more effective than generic feedback. The second feature is a session limit that was designed to prevent users from "binging" the game, because this could prevent deep learning.

3. METHODOLOGY

In this section, we present the gamification concepts and game design mechanics that would be beneficial in improving user engagement.

3.1 Gamification

Gamification has been around for quite a long time. Recently, gamification has been applied in many contexts to achieve various goals. For example, education [33] [34] [35]; risk management [36]; solving usability issues [37]; and marketing [38]. According to [39] definition, gamification is seen as a packaging for a service. The core service is enhanced by a rules-based system

incorporating feedback and interaction mechanisms. Nonetheless, when discussing gamification, it should be noted that it involves the game design elements rather than playful design, which often lacks structure, goals, or both [40]. Gamification applies the dynamics and mechanics of psychology that make games so engaging and sticky. It is the means to provide information into the system and facilitating the process that engages that kind of sharing. Gamification typically makes more sense when game design thinking is applied to non-gaming applications like enterprise business applications, collaboration and communication application suites and so on.



Figure 1: Gamification Overview

3.2 Differences between Gamification and Serious Games

There are some similar concepts - gamification, game inspired design, serious games, simulations and games - whose boundaries are not precisely defined. But they have one thing in common – the use of elements essential in games and their purpose is to support learning and to improve users' engagement [41].

1. **Game inspired design:** This is the used of ideas and ways of thinking common to games, without adding new game elements; but uses a playful design.
2. **Gamification:** This is the used of game elements and ideas in a different context in order to increase motivation and commitment, and influence user behavior.
3. **Serious games:** These are purpose driven games design such as training, and not just for fun. They possess all resemblance of a game, but their objective is to achieve a predetermined goal.
4. **Simulations:** These are used to simulate real-world scenarios. with purpose is train users in an environment resembling real life.
5. **Games:** These are designed for entertainment and includes everything mentioned above.

3.3 Conceptualizing Gamification

Gamification is much more than simply rewarding points and badges; it is about

understanding and influencing the human behaviours that companies want to encourage among their users. Gamification is founded in the fundamentals of human psychology, behavioural science, computer science as well as motivation, ability level and triggers. For a behaviour to change, three things have to be present: a trigger, the ability to do the behaviour, and motivation. And the last two, motivation and ability, are trade-offs. That means if you have low amounts of ability, you need to have more motivation. If you have low amounts of motivation, you need to make the behaviour steps really small. When done correctly, gamification provides an experience that is inherently engaging and, most importantly, promotes learning. The elements of games that make for effective gamification are those of storytelling, which provides a context, challenge, immediate feedback, sense of curiosity, problem-solving, a sense of accomplishment, autonomy and mastery [42].

3.4 Game Mechanics and Dynamics

Defining game mechanic has proven to be rather problematic. As such, there has been a number of attempts to defining game mechanics. The game mechanics and dynamics include statistics, points and scores, leaderboards, achievements and badges, tasks and quests, progression, and challenges. While many elements shared similarities, the usage of elements varied from site to site. A thing worth noting about game mechanics and dynamics is that in almost all cases, multiple mechanics and dynamics are used jointly [10] [43].

1. Reward and Incentive

To stay competitive, reward campaigns are run to offer discounts, promotions and incentives to users through Loyalty programs. Rewards structure that encourages desired behaviors in user-facing environment are designed. Some prefer to design two level reward mechanisms - Badges for adoption and frequency of use on particular platform and Points for desired action within the platform.

2. Tasks and Achievements

Achievements or Badges are to reward users for completing certain tasks or milestones. However, badges are not used only as merits for completed tasks. When badges are used as rewards, certain tasks are usually involved. These tasks are usually ranging from arbitrarily easy to requiring constant participation in the community. Tasks are called quests and they offer an exercising challenge to take on. The quests are easier at first and get

progressively more difficult when they are completed.

3. Leaderboards

It is an emerging practice in forward-looking applications to assign leaderboards in different areas of domain expertise across application functions. People normally like to validate if they are performing well as per expectations or not. Leaderboard helps people to know where they stand relative to their colleagues or peers thereby inculcating a spirit of competition.

4. Contests

This is a combination of missions that reward those who finish most quickly or effectively.

5. Competition

Competition is used to encourage users to perform better than other users. In some cases, the competition element is closely tied to the scoring system used.

6. Challenges

Challenge is a mechanic that differs from competition. While competition is an on-going state between users, a challenge is a fixed form of competition where participants have a limited set of resources to accomplish pre-defined goals.

7. Co-operation

Co-operation, on the other hand, is used to encourage users to work together to achieve their goals. The use of co-operation is most notable in collaborative projects, which rely on the users to create and maintain the core content.

8. Social Connection

Social Connections leverage social networks to create competition and provide customer support. With the high penetration of mobile web and high adoption of mobile devices and tablets, social networks may provide instant access to social connections anytime anywhere which increases the level of engagement and interactions

9. Levels & Reputation

It signifies the level of user engagement across the value chain which becomes a basis for awarding the players once they reach a specified level. Reputation is the clear measure of the trust build in the community and gives standing of relevance of your questions and answers in right context.

10. Progression

A common use for progression is a progress bar showing the status of a set of tasks the user is

encouraged to perform. Progress can be used to encourage users to use features, to purchase paid features or to gather information from the users.

11. Notifications

To encourage engagement when users perform a desired action.

3.5 Categories of Achievements

Typically, achievements fall into several categories include [44]:

1. Tutorial achievements awarded for trying out the features of the game,
2. Completion achievements awarded for completing tasks,
3. Collection achievements awarded for obtaining items,
4. Virtuosity achievements awarded for exceedingly exceptional (for example, not dying at all),
5. Hard mode achievements awarded for succeeding on high difficulty,
6. Special play style achievements awarded for playing the game in a certain way (for example, against a timer),
7. Veteran achievements awarded for playing the game for prolonged amount of time,
8. Loyalty achievements awarded to players being loyal to the game and the community (for example, subscribing for a prolonged period of time),
9. Curiosity achievements awarded for doing something abnormal (for example, jumping from great distance without dying),
10. Luck achievements awarded for acquiring something rare (for example, rare items),
11. Mini-game achievements awarded for succeeding in mini-games,
12. Multi-player achievements awarded for excelling in multi-player game modes,
13. Paragon achievements awarded to a few top players for accomplishing something extremely difficult or rare (for example, being the first player in the world to complete a task),
14. "Fandom" achievements awarded to players who perform fan activities (for example, participate in game conventions or purchase collector's editions).

Motivation to acquire badges stems from multiple aspects. They can work as symbols for social status among players, invoke "completionism", that is, drive players to complete as much of the game as possible, and they can also extend the play time by providing new ways of

playing the game [45]. Achievements are merely trophies in a sense that they do not provide new functionality, although some games do incorporate achievements, providing more motivation to the players. Achievement systems do require certain properties to function well with the players. For example, when player completes an achievement, they should be notified immediately and explicitly to reward the player, to remind the player of the existence of the achievements and to "arouse their curiosity towards achievements" [44].

4. DISCUSSIONS OF FINDINGS

In this section, we present a theoretical framework of gamification, comparing its operational characteristics with that of Finite State Machine, and a case on Gamified Social Networking Concept.

4.1 Theoretical Framework of Gamification

Consistence is essential to all application that implement any gamification protocol. Otherwise, a user might behave in an unexpected manner. Logically, there are standards that describe the operation of each protocol. The problem with a protocol like gamification is that it performs so many tasks that it is difficult to specify the exact operation of all aspects of the protocol concisely.



Figure 2: Key characteristics of Game Design

Using A Finite State Machine to Explain Gamification Concept

How gamification works can be explained through a theoretical tool called a finite state machine (FSM). An FSM attempts to describe a protocol or algorithm by considering it like a virtual "machine" that progresses through a series of stages of operation in response to various happenings. Likewise, gamification describes various game design mechanics by combining them through a pre-defined series of stages of operations in response to pre-defined activities.

Table 1: A Comparison of the Operational Characteristics of Finite State Machine and Gamification

Finite State Machine	Gamification
State: The particular “circumstance” or “status” that describes the protocol software on a machine at a given time.	Resource Management (time, effort and Status): This shows the level of effort that is required to complete certain tasks.
Transition: The act of moving from one state to another.	Goals: These are defined for users, and are used to monitor their behavior and reward them on their achievements.
Event: Something that causes a transition to occur between states.	Information: Games provide player the most relevant information to make decisions appropriately.
Action: Something a device does in response to an event before it transitions to another state.	Rules: Each game has a series of rules provided by game designer which are applied by the player.

Gamification describes the game design mechanics by explaining the different resources required to complete a task; information to make appropriate decisions; series of rules to be applied when deciding and goals to achieve as a result. The process usually starts in a particular beginning state at first run. It then follows a sequence of steps to get it into a regular operating state, and moves to other states in response to particular types of input or circumstances. The gamification is called finite because there are only a limited number of states.

4.2 Case: Gamified Social Networking Concept

The initiative behind the gamified social networking – “a real-time online platform to foster interactions between users from any geographical location”. This is achievable by creating a gamified social networking platform which can be accessed via any internet enabled device. This gamified platform employs a number of game mechanics such as tasks, contests, competitions, points, voting, leaderboard, achievements and badges. The gamified platform consisting of a number of tendencies and accompanying game mechanic suggestions that can be used to potentially improve user engagement. By selecting the game mechanics that most closely match the motivational and behavioral tendencies of the specific users. To achieve the greatest improvement possible, the

gamified design would likely need to consider users of different personality types. This should be possible in a research setting but more difficult in a commercial endeavor. However, if the target market of a commercial gamification attempt is focused enough, it should be possible to make reasonable assumptions about the users within that market.

The gamified platform gives users an entertaining experience in real-time as they partake in tasks, competitions, contests and challenges. Users will be able to perform CRUD (Create, Read, Update and Delete) operations; vote and be voted for; get points for winning, get achievements for completing pre-defined task, get badges as they attain more points and also get notifications on interactions and activities; giving them an entertaining gameful experience.

4.3 Benefits of the Gamified Social Networking Concept

- User benefits** includes but not limited to a convenient, interactive, creatively fun yet user-friendly environment, get inspiration, reduces the complexity of operations, and also be a member of an online community.
- Business benefits** includes but not limited to predictability of demand for product, easier and cheaper to plan and participate in creative competition, increased competitive frequency and user lifetime, and fostering loyalty.

Table 2: Three Main Drivers of the Gamified Social Networking Concept

Key Drivers	Antecedents	Attributes
Intrinsic motivation	Autonomy, Competence and Relatedness	Reward, Level, Reputation
Game mechanics	Space, Objects, Actions, Rules and Skills	Points, Badges, Achievements, Leaderboard, Voting
Immersion Dynamics	Story and Aesthetics	Task, Contest, Competition, Challenge

In order to provide a summary of the important properties in the gamified social networking concept and better assess the game design mechanics taken from the literatures. These properties are then organized into five categories:

Table 3: A Summary of Important Properties

Categories	Attributes
Economics	Objectives, Viability, Risk, Return on Investment, Stakeholders
Logic	Loop, End game/Epic win, On-boarding, Rules
Measurement	Metrics, Analytics
Psychology	Fun, Motivation, Social, Desired behaviours, Ethics
Interaction	Narratives, UI/UX, Technology

Table 4: Categorization of Literature Reviewed

S/N	Application Area	Game Design Mechanics	Literatures Reviewed
1	Education	Social Connection, Notification, Competition	[19]
		Leaderboard, Badges	[22]
		Points	[21]
		Task, Badges	[23]
		Competition, Level	[7]
		Leaderboard	[30]
		Notification	[46]
2	Healthcare	Points	[27]
3	Business	Progression, Reward, Notification, Social Connection	[20]
		Competition	[26]
		Points	[29]
			[31]
4	Web/Mobile Application	Co-operation	[24]
		Mission	[28]
5	Theoretical Application	[25]	

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

Gamification informally refers to making a system more game-like. More precisely, gamification denotes the application of game mechanics to a non-gaming system. We theorize that gamification success depends on the game mechanics employed and their effects on user motivation and immersion. Based on our research into gamification, we presented theoretical framework for the effective application and understanding of gamification. The theoretical framework suggests that gamification has automata theory as one of its core principles, contributing to any explicit goals of the system and the goals of its users. A case of gamified social Networking concept was presented. This gamified social networking concept posits three main drivers: intrinsic motivation, game mechanics and immersive dynamics. For effective engagement with the gamified system, the user must receive and process feedback, that is, information given to the user after certain participations. Poor feedback can lead to reductions in user engagement and even failure of a gamification platform. If the system has an explicit purpose, gamifying it is effective to the extent that it contributes to this purpose. As well as, aligning the purpose of the gamified system with the goals of the user.

5.2 Conclusion

In gamification, rewards have a strong impact on individual experiences, and when employed in any scenario, may lead to addiction, or escapism, which could represent a number of outcomes. Therefore, game designers should explore the consequences of their designs, both in the long term and short term. Especially, when transferring extremely effective game design mechanics from a domain to another one. It is noteworthy that making an experience more enjoyable and engaging may not be a valuable outcome as such; likewise, “increasing the performances by exploiting “fun” elements could not be always desirable; and using a game framework could also turn an experience sour. Moreover, gamification design appears to be informed by a variety of assumptions [47]:

- individuals are users, workers, or consumers that somehow need to be “enhanced” (in their performances, motivations, and so on);

- games or game design mechanics might make a behavioral intervention more acceptable and somehow less questionable;
- a gamification should be applicable to every domain.

Such presumptions need to be critically discussed by researchers and designers, in order to make gamification techniques more effective and pervasive.

5.3 Recommendation

The proposed case of gamified social networking concept needs empirical testing to determine its veracity. Future work may therefore include design, implementation and user testing.

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