AN EXPERT GAMIFICATION SYSTEM FOR VIRTUAL AND CROSS-CULTURAL SOFTWARE TEAMS

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ABSTRACT

Gamification is the concept of applying game elements in non-game context platforms to motivate people to participate in planned activities to achieve goals.

Gamification has been applied to academic fields including software engineering (SE) in recent years. Many gamification implementations in SE have been ad hoc and lacked standardized guidelines. This paper introduces a new concept of building an expert gamification system (EGS) to provide guidelines for the implementation of gamification for virtual and cross cultural software teams (VCCST). The system will extend the core of a regular expert system to include gamification tools, a supplementary database, and an expert knowledge source. The cross-cultural data for the EGS contains the Hofstede's cultural dimensions (HCD).

As more and more VCCST are formed in recent years, many issues have been raised in those teams stemming from miscommunication and cultural conflicts. This paper uses the EGS to help resolve the issues in VCCST.

KEYWORDS

Gamification, Software Engineering, Expert System, Hofstede's Cultural Dimensions, & Theory of Flow

1. INTRODUCTION

Gamification is the use of elements of game design in non-game contexts [1]. It is the application of game elements used to encourage engagement with a product or service. The concept of gamification has been around for more than a decade. There has been a great deal of commercial and academic interest on the use of gamification in recent years.

Some studies show that gamification can motivate engineers in SE if applied appropriately. However, many gamification implementations for SE are lacking a well-defined framework or guidelines. This paper develops an EGS that will provide guidelines for implementing gamification for VCCST.

An expert system is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge

[2]. This paper extends the core of an expert system to include gamification tools, a supplementary database with the cross-cultural data, and the expert knowledge source from theory of flow to build the EGS. The core of an expert system consists of the inference engine and the knowledge base. Figure 1 is a high-level view of the EGS.
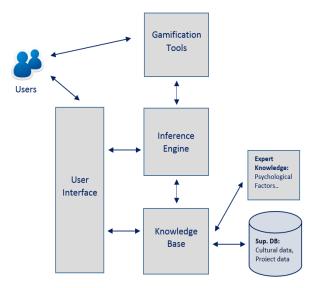

Figure 1. High Level View of the EGS

The EGS consists of the following modules:

1. Gamification Tools
2. User Interface
3. Inference Engine
4. Knowledge Base
5. Supplementary Database
6. Expert Knowledge Source

2. RELATED WORK

Gamification has been extensively researched by different types of researchers in recent years. However, there are very few studies in building an EGS as a tool for implementing gamification. Some gamification studies are intended for learning and discussed in the context of education. Other work tried to verify whether or not gamification works [3]. Some analysis has been done to investigate the gamification mechanisms and see how gamification influences behaviours [4]. Some research has indicated that gamification provides positive effects in motivation. Some studies are descriptive in nature and they have no actual listed experiment results of gamification reported [5], [6], [7], [8]. Several studies explore conceptual frameworks for classroom learning only [9].

For VCCST, some studies describe their conflicts and issues in detail but offer little help or guidance for them [10], [11]. Other research identifies the specific attributes relevant to cross-cultural concerns but does not show how to resolve the issues [12]. Some studies describe how to do cross-cultural surveys [13]. There are very few studies offering solutions for using an EGS.

3. VIRTUAL AND CROSS CULTRUAL SOFTWARE TEAM

Globalization of markets has been a major theme in recent years and more software teams are working in cross cultural environments from outsourcing or insourcing work strategies [10]. It is common for a large software project to have teams in more than one location and in different countries. Many VCCST are formed across the globe with engineers from different parts of the world [14]

It has been reported that the software projects with VCCST have quite a few issues and challenges.Most of the problems are about conflicts in culture and its adverse impact to the dynamics of the team [10], [15]. In a few instances, the software engineers view their co-workers from different cultures as rivals rather than teammates. This paper designs an EGS to promote team work and collaboration for VCCST to smoothen their conflicts and problems.

4. EXPERT GAMIFCATION SYSTEM

The EGS extends the core of an expert system and consists of six components as shown in Figure 1. The core elements of an expert system are the inference engine and the knowledge base. The inference engine is an automated reasoning system that evaluates the current state of the knowledge base, applies relevant rules, and then asserts new knowledge into the knowledge base. The knowledge base represents facts and rules. Knowledge in an expert system may originate from many sources such as reports, databases, case studies, empirical data, and domain experts [2].

Other components in the EGS are the gamification tools, a user interface, a supplementary database, and an expert knowledge source. The gamification tools include the game mechanics and the platform. For example, Microsoft SharePoint can be used as a gamification tool. These tools will contain the software team profile and personal profiles. The profiles will store and show the team scores and individual scores respectively. The user interface facilitates the communications between the project admins, users, and the EGS.

The supplementary database contains the cultural data and project data. The expert knowledge source contains the theory of flow information. The following two sections describe the cultural data and the theory of flow for this EGS.

4.1. Hofstede's cultural dimensions

Hofstede's cultural dimensions (HCD) theory is a framework for cross-cultural communication. It describes the effects of a society's culture on the values of its members, and how these values relate to behaviour using a structure derived from factor analysis [16]. According to Hofstede the most important differences between cultures can be captured by finding to what extent members of these cultures differ with regard to six values [17]:

1. Power distance index (PDI) - The power distance index is defined as the extent to which less powerful people in an organization will accept and expect power to be distributed.

2. Individualism/Collectivism (IDV) – Differences between the degrees within the Individualism vs. Collectivism index.

3. Masculinity/Femininity (MAS) - Differences between the degrees within the Masculinity vs. Femininity index.

4.   Uncertainty avoidance index (UAI) - Differences between the degrees within the Uncertainty Avoidance Index.

5.   Long-term/Short-term Orientation (LTO) - Differences between the degrees within the Long-Term vs. Short-Term Orientation index.

6.   Indulgence vs. Restraint (IND) - Differences between the degrees within the Indulgent vs. Restraint index.

Table 1 shows the Hofstede's values for these cultural dimensions for Australia, China, India, Japan, Netherlands, UK, and USA [17]. The EGS further categorizes the countries into regions such as Australia (AUS), Asia, Europe (EU), and North America (NAM) for further region processing as shown in the second columns of Table 1.

Table 1. Hofstede's Cultural Dimensions

Country	Region	PDI	INV	MAS	UAI	LTO	IND
Australia	AUS	36	90	61	51	31	71
China	Asia	80	20	66	30	87	24
India	Asia	77	48	56	40	51	26
Japan	Asia	50	42	90	88	75	42
Netherlands	EU	38	80	14	53	67	68
UK	EU	30	89	62	30	20	69
USA	NAM	40	91	62	46	26	68

Among the HCD, three dimensions have more effect on gamification. They are Individualism, Masculinity, and Uncertainty:

1. Individualism (INV)

This is the index to indicate how people think with the mentality of "I" or "We." Some countries are very "individual" focused. They focus more on themselves and careers versus their group. The game design should take this into consideration. If the culture is more individual focused, game mechanics such as leaderboards should be used.

2. Masculinity (MAS)

Masculinity is defined as "a preference in society for achievement, heroism, assertiveness and material rewards for success." Its counterpart represents "a preference for cooperation, modesty, caring for the weak and quality of life." [17] This dimension gives important information in setting up the right game mechanics for certain cultures. For instance, many Scandinavian countries have a very low score in MAS. In those cultures, there is an important concept known as Janteloven [8]. Janteloven is essentially a set of rules for encouraging social equality, social stability, and uniformity in which one should never try to stick out from the crowd.   The Netherlands is an example with a score of 14 in MAS. The EGS should take this into consideration by not focusing the games on competitiveness and leaderboards. Rather, it should promote notions of equality and creativity for them [18], [19].

3. Uncertainty Avoidance (UAI)

The uncertainty avoidance index is defined as "a society's tolerance for ambiguity" in which people embrace something unexpected, or go away from the status quo. Societies that score a high degree in this index tend to prefer strict codes of behaviour, guidelines, laws, and absolute

Truth. A lower degree in this index shows more acceptance of differing thoughts. Society tends to impose fewer regulations, ambiguity is more accustomed to [17]. The game design should take this into consideration.

4.2. Psychological factors and flow detection

Gamification uses the psychology of engagement to motivate people. Psychology can be applied to the non-technical aspects of SE like personality, teamwork, leadership, decision-making, culture, motivation and human tendencies [15].

Abraham H. Maslow was a renowned psychologist in the field of motivation. He published the famous Hierarchy of Needs in 1943 [18]. It is a pyramid depicting the five levels of needs, namely

1. Biological and Physiological: air, food, shelter, water, sex, & rest

2. Safety: health, protection, stability, freedom from fear & security

3. Love and Belonging: love, intimacy, friendship, family, & affiliating

4. Esteem: self-esteem, independence, status, confidence, achievement & respect

5. Self-actualization: realizing personal potential, self-fulfilment & peak experiences

Self-actualization is the peak level in which a person's full potential is realized. Maslow describes this level as the desire to accomplish everything that one can: to become the most that one can be [18].

4.2.1. Theory of flow and group flow

Self-actualized people are those who come to find meanings to life that are important to them and that fulfil them. Many of them experience a common phenomenon called flow, proposed by Csikszentmihalyi [20].When people are in a state of flow, they will feel focused and concentrated. They may feel a sense of ecstasy, great inner clarity, a sense of serenity, timelessness, and intrinsic motivation. The flow is the balance between the skill level and the challenge of a task. When a task is too difficult, it causes people to worry. When a task is too simple, people will be bored. When a task is balanced between skill and difficulty, the individual will reach a state of heightened focus and immersion [20]. Some research further extends the flow theory for groups. Keith Sawyer developed specific triggers needed for creating group flow [21]. Figure 2 shows the theory of flow. The EGS should try to keep the team in the flow and should be able to detect the flow zone.
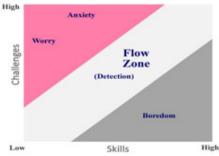

Figure 2. Flow Theory

4.2.2. Flow Zone Detection

The EGS should find ways to measure and detect the flow zone. There are some methods in measuring flow with questionnaires: Nakamura & Csikszentmihalyi enlist the various ways of measuring flow for Concept of Flow; Intrinsic Motivation Inventory with 10 Questionnaires; John Marshall Reeve: Agentic Engagement Scale Questionnaires; Davin Pavlas Play Experience Questionnaire [21]. Other than using the questionnaires, the EGS can use the game statistics to detect the flow zone. Figure 3 shows a simple game flow in which the 'flow' loop is indicated with bigger arrows.
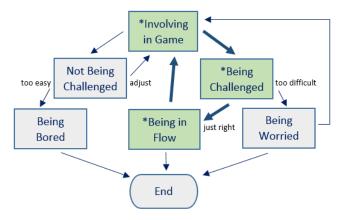

Figure 3. A Simple Game Flow

The EGS should monitor the game and collect the game statistics. The EGS should set up rules to determine if a team is in a flow state. Table 5 shows a sample of the game statistics. The average percentage of hits in that table can be a strong indicator for detecting a flow state. For example, if that percentage is at least at a certain value, then the EGS should assume that the team is in a flow state or zone. It may be a trial and error process to finalize the right value for that percentage. The percentage can be cross checked with the questionnaire method to find the optimal value.

4.3 Determining Game Mechanics and Activities

The EGS should extract the cultural information and use that information to configure the game mechanics in the system. Table 2 contains the game mechanics, the associated emotions, and their values for INV, MAS and UAI. The values represent the recommendations from the EGS for the game mechanics. For example, the value of 'all' in INV means that game mechanic is good for all values of INV. The value of 'high' in INV means the game mechanic is good if INV is high. The same rule applies to the value of 'low'. If all three HCDs have the same 'high' value for the same game mechanics, it reinforces the recommendations. If the HCDs have different recommendations, INV will have the highest preference and MAS will have the second highest preference.

Table 2. Game mechanics and cultural factors

Game mechanics	Emotions	INV	MAS	UAI
Points	Reward	all	all	all
Badges	Achievement	all	high	all
Leaderboards	Competition	high	high	high
Levels	Status	high	high	high
Progress bars	Achievement	all	all	high
Storyline	Engagement	all	all	all
Feedback	Engagement	all	all	high

Challenge/between users	Competition	all	high	all
Virtual gifts	Altruism / Self-expression	all	low	low
System for sharing/exchanging	Collaboration/ Community	low	low	all

Table 3 shows a list of activities with their corresponding values for INV, MAS, or UAI. The rules for recommendation are similar to the ones in Table 2. For example, the value of 'low' in INV for 'helping others' means that activity is recommended when it has a low INV value. The same rule applies to other activities and HCDs. Also, the HCD values in the table can be changed when more knowledge or experience is gathered.

Table 3. Activity table with cultural factors

Activities	INV	MAS	UAI
Inviting peers to design review	all	all	all
Participating in a design review	all	all	high
Inviting peers to a code review	all	all	all
Participating in a code review	all	all	all
Inviting peers to a test plan review	all	all	all
Participating in a test plan review	all	all	all
Helping others	low	low	all
Giving people credits	low	low	all
Being a team player	low	low	all
Resolving issues	all	low	high
Collaboration activities	low	low	all
Innovative idea	all	all	all
Voting for an idea	low	low	all
Beating the deadline	high	all	high
Documenting code	all	all	high
Best practice	all	all	high
Writing unit tests	all	all	high

4.4. Sample Data

A simple prototype is developing at this time. The preliminary findings are encouraging. Table 4 contains some sample inputs to the EGS for demo purpose. These inputs drive the EPS based rules mentioned in 4.3 and the 4.2.2 example.

Table 4. Inputs to the system

Attributes	Examples
Project Name	VCCST Enhancement
Project Description	A demo to show how the EGS works
Domain of interest	Software engineering
Team Info	Cross-Cultural
Team Location	Virtual
Countries	USA, India, China
# of team members	20, 12, 18
# of analyst, developers, testers	4,12,4
SE Methodology	Agile

The ESG will recommend a list of game mechanics and activities for the software project. Each individual group is customized. The EGS collects statistics from the project for analysis. One of the important tasks is to detect the flow zone for the software project team.

Table 5 shows a sample of the game statistics. The EGS uses the values from INV, MAS, UAI, and the team cultural data to determine the initial 'target %' for the flow zone. As more project data are stored and accumulated, the EGS can use the past data as reference and knowledge for further 'target %' refinement and fine tuning. If the HCD recommend the activities, the 'target %' for those activities will be higher than others.

Table 5. Sample game statistics

Point for activities	# of players	# of hits	Hit %	Target hit %
inviting peers to design review	16	15	93.75	80.00
participating in a design review	16	9	56.25	80.00
inviting peers to a code review	12	8	66.67	80.00
participating in a code review	12	6	50.00	80.00
inviting peers to a test plan review	16	7	43.75	80.00
participating in a test plan review	16	4	25.00	80.00
helping others	20	6	30.00	70.00
giving people credits	20	15	75.00	75.00
being a team player	20	9	45.00	75.00
resolving issues	20	5	25.00	70.00
collaboration activities	20	12	60.00	70.00
innovative idea	20	3	15.00	60.00
voting for an idea	20	4	20.00	70.00
beating the deadline	20	4	20.00	80.00
documenting code	12	8	66.67	80.00
best practice	16	5	31.25	75.00
writing unit tests	12	11	91.67	80.00
Average %:			47.94	75.59

A: Number of analysts	4
B: Number of developers	12
C: Number of testers	4
D: Total players	20

In Table 5, the 'Hit %' is calculated by '# of hits' / '# of players'. In this sample data, there are 4 analysts, 12 developers, and 4 testers – a total of 20 players. The system assigns players to the activities according to their roles. The system collects the games statistics including the number of hits from each activity. The system compares the average 'Hit %' and the average 'Target hit %' to determine the status of the flow zone. In Table 5, 47.94% is the average 'Hit %' and 75.59% for the average 'Target hit %'. Since the average 'Hit %' is lower than the average 'Target hit %', the EGS will infer that the project team is not in a flow zone. The EGS will send alerts to the system admins and project managers. They can choose to adjust the game mechanics/activities and or make comments about the project. The project data will be stored and served as reference and knowledge data for future projects. A SharePoint community site will be used as a platform for collaboration, community, and data collection.

5. CONCLUSIONS

This paper introduces a new concept for building an EGS for the implementation of gamification for VCCST. The goal of this paper is to open up another way of thinking in designing gamification for SE using cross cultural data, the flow theory, and the past project data for the VCCST.   Designing and building the EGS will help to create a user-friendly system tool for gamification implementation. The concept can be further extended to other domains for resolving different problems using gamification.

For future work in this EGS, one area to investigate is how to better detect the state of flow and group flow using the project data or other means. A more formal algorithm should be developed for that. Also, incorporating more cultural data to develop a robust knowledge extraction methodology for the system could be beneficial. As for the VCCST, more case studies should be done using gamification with qualitative and quantitative approaches. Supporting and fostering the gamification research to improve the software development process in the cross-cultural environment could yield impactful results for VCCST's.

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