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Towards a new software quality model for evaluation the quality of gamified systems

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Abstract

Due to the emergence of the Gamification concept in various domains, this article studies how to improve the quality of gamified systems with the software engineering discipline.

Recent studies have shown a significant gap between design frameworks and gamified products, reflected in a lack of consistency, integrity, measurement and a comprehensive process that covers the different phases to achieve a quality gamified product. For this purpose, a specific quality model software for evaluation is required.

Our contribution consists of making an analytical and qualitative study of the existing Gamification frameworks and platforms, with the aim of proposing a model for quality evaluation of the gamified applications. This proposal is based on the patterns and attributes determined during the conducted bibliographic study and comparative studies, with an attempt to integrate the ISO 25010 quality model.

Keywords: Gamification, Gamification framework, Gamification process, Gamification tools, Software quality models, Software engineering.

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1. Introduction

Launched a few years ago, the Gamification concept is now experiencing a new evolution and seems to be emerging as a strong and scalable trend in many domains, including marketing, business, training, and human resources management. This concept can be described as the use of game elements in a non-game field to enhance the engagement of the user's experience [1]. As an example, it can be used in marketing to attract customers and gain their loyalty, or to engage employees in the business field. Practically, all sectors of activity could benefit from Gamification as it can help achieve three main business objectives: 1) changing behavior; 2) developing skills; 3) Or enabling innovation [2].

This trend has upset many markets and offered new development opportunities. According to a recent study conducted by the Technavio research center, the market will exceed 6 billion dollars by 2019, with a growth rate of 48% since 2016. It is also noted that the US and Asian markets appear to be the most dynamic in the subject [3]. According to the report, one of the main drivers of market growth is the need to improve customer's interaction [4].

This "Gamification" has already been successfully adopted in several large organizations and had many positive results, including better long-term collaboration, creativity, productivity, loyalty and learning. [5] On the other hand, many software projects still fail today to deliver on time, with the expected costs and scope. One of the main reasons behind the failure of these projects is that they do not meet requirements, often caused by insufficient stakeholder collaboration, incomplete understanding of needs, insufficient knowledge and other [6].

In 2014, Gartner predicted that 80% of Gamification initiatives in the company will fail, pointing out that bad design is the main cause of these failures; hence the importance of establishing a clear design strategy to successfully implement Gamification [2]. However, existing studies focus primarily on experiences in areas such as education, marketing, sales, energy and health. Little research has been initiated on the relationship between Gamification and software engineering discipline; even less have targeted the use of software engineering as a tool at the service of Gamification to design products of good quality.

Therefore, this article will specifically focus on the quality of processes and framework of gamified software development, and on the contribution of the scientific software engineering discipline to a systematic and effective development of this type of application. This study focuses on the existing quality models in order to propose a new quality model specific to the Gamification concept, while responding to these different characteristics.

2. Related works

At this point, it can be argued that it is necessary to evaluate the current state of the art of quality models of the Gamification concept. It is important to determine the most consolidated body of knowledge and the most remarkable gaps to be filled. It seems that researchers have not shown the same interest in evaluating these qualities despite their growing interest in gamified software.

After analyzing the state of the art of the gamified software quality, we noted a remarkable lack of quality assessment tools for gamified products. Only few quality models take into account quality characteristics and attributes specific to gamified software, and more precisely the models supporting our proposals. Despite the wide scope, we have explored various well-known scientific databases including IEEE, ScienceDirect and Spring, only one attempt to customize the quality models for the Gamification frameworks has been identified; which is the QU-GamSoft model. The latter represents an adaptation of the Use Quality model (ISO, 2011b) that takes into account the specific quality attributes and characteristics of gamified software.

To fill this gap, we propose a customization of the ISO 25010 model, consisting of nearly the same data quality characteristics, to assess the quality levels of data used in Gamification projects. Unlike the QU-GamSoft model [28], our proposal is distinguished by:

- A justification for the choice of the basic model after studying a set of existing quality models.
- A multi-dimensional attributes mapping approach (conceptual, analytical and qualitative)
- Proposal of a new quality model, richer in features and characteristics, to cover different aspects of a gamified software product, and to target more precise measures at the application level; unlike the QU-GamSoft model which is more interested in the use quality of a product regarding its users (satisfaction, risk, ...)[27]

The proposed model can be integrated into any Gamification project because it is independent of any pre-conditions or technologies. A more detailed sheet of the proposed model specifics is to be presented throughout the article.

3. General Research Methodology

This article studies the integration of the software engineering discipline with Gamification in order to build a well-designed, more engaging and motivating gamified software. Our contribution is limited to studying the quality of the existing frameworks and gamified products towards proposing a new personalized quality model.

The research will be carried out qualitatively through reviewing the results of comparative studies of existing quality models, the characteristics of the ISO 25010 quality model, conceptual frameworks and experimental studies on gamified products. The following figure summarizes and lists the steps of our research:

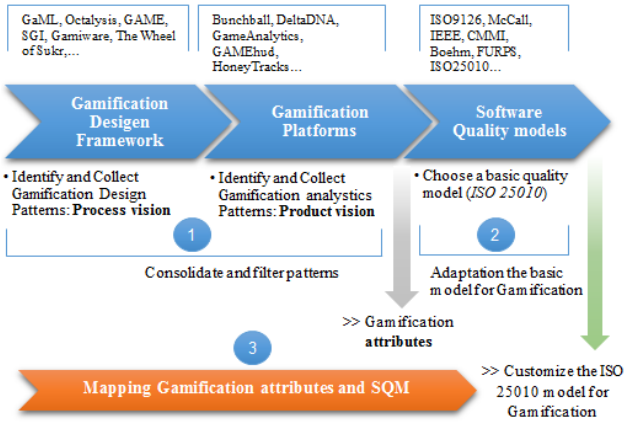


Figure 1: Synthesis of our working methodology

As presented in Fig 1, the different steps below explain our approach and methodology of research and analysis:

Step 1 : Definition of Gamification attributes

This first step is to define the attributes for Gamification concept. Based on existing studies of different frameworks and Gamification platforms, we have extracted a set of patterns considered important to the evaluation of a gamified product.

Step 2: Choose a basic quality model

In addition to the previously proposed attributes, we have chosen to reinforce our proposal with a software quality model. It is a question of choosing a quality reference

model on which our attributes will be projected. The choice was mainly based on the recommendations of the comparative studies on the existing quality models for the software engineering domain, in addition to the following two main criteria:

- The reference model must be rich in features in order to increase the possibility of covering the majority of the Gamification attributes and minimize the additions, modifications or adaptations to be brought.
- The model must cover the maximum of phases of the software lifecycle.

Step 3: Customize the ISO 25010 model for Gamification

Given the particularity of our field of study, "Gamification" and the "Software engineering" discipline, the quality model chosen as referent requires certain modifications, deletions or adaptations of its characteristics or sub-characteristics to respond to the context of study. This step aims to customize the ISO 25010 quality model following a mapping between its characteristics (or sub characteristics) and the Gamification attributes.

4. Gamification Attributes

The definition of the Gamification attributes required an analysis that includes both design frameworks and Gamification platforms. This scope was chosen in order to cover the characteristics of a product during the different phases of its life cycle. The analysis of the Gamification design frameworks allows a first vision of the main patterns that concern the phases of needs expression, design and needs analysis. This vision has been completed with a second study that is oriented to Gamification platforms, and that covers the other phases of testing, implementation and continuous improvement.

a) Gamification design patterns:

As mentioned before, we start with an extraction of the list of patterns from an analysis of the Gamification design frameworks. As shown in Figure 2, the following steps outline the approach used to obtain the list of Gamification design patterns:

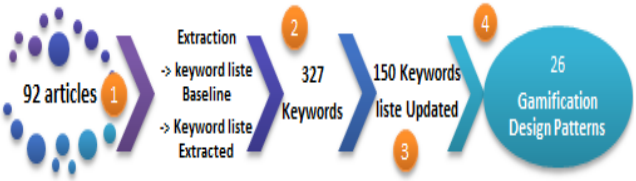


Figure 2: extraction step of gamification design patterns

Step 1: Research and analysis of articles on Gamification design frameworks for pattern extraction related to the Gamification concept. The research was based mainly on:

• The most well-known scientific databases in this field, including: IEEE Xplore Digital Library, Springer, Science Direct, ACM Digital Libray, Google Scholar, etc.
The following search string: Gamifying (OR Gamification OR gamified) AND Framework (OR model, OR process, OR software, OR design).
Eventually, we obtained 92 candidate articles for analysis.

Step 2: From the lists of articles obtained, we extracted the keywords explicitly specified by the authors and others following a diagonal reading of the whole document. 327 keywords were obtained.

Step 3: In this step, a first level of filter has been performed, consisting of deleting duplicates and classifying keywords according to several criteria, for example:
- Application area: Learning, e-commerce, Health, ...
- Life cycle: Design, Implementation, Improvement
- Framework: Octalysis, Serious Game, user experience,..
- Psychology like: Fun, Self-determination, ...
- Characteristics (patterns): Player types, Intrinsic motivation, Badge, game elements, measures, ...

This step has allowed us to reduce the keywords list to 150 items.

Step 4: Based on the inclusion and exclusion criteria defined to meet the need of our study, 26 keywords are obtained (see figure 3). Below, more details about the criteria used in the filter are to be found:
Inclusion Criteria: Recurring keywords that may represent one of the Gamification characteristics related to one or more phases of a product's life cycle.
Exclusion Criteria: keywords that do not represent Gamification characteristics, especially those that specify the application domain, phycological reference theory, other frameworks (example: Octalysis, Serious Game, user experience , ...)

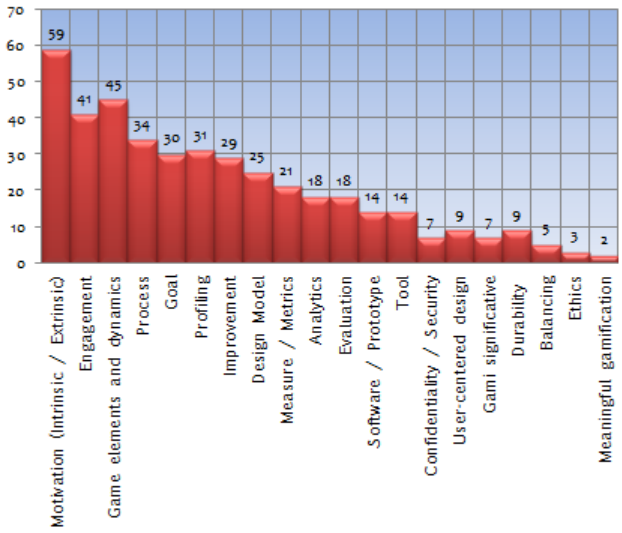


Figure 3:Gamification design patterns

b) Gamification experimental patterns:

This second section targets a recent study by Philipp Herzig that focuses on an analytical study of the Gamified products using new tools that were proposed and validated by 10 experts actively working in the field of gamification, particularly:

- Bunchball Nitro
- Analytics,
- Gigya
- Gamification Analytics,
- DeltaDNA,
- GameAnalystics,
- GAMEhub,
- HonyTracks,
- Upsight,
- Assessment Result Summary.

To analyse these tools, Philipp Herzig [25] and al proposed the following evaluation tool:

Table 1. Gamification Measurement Product [25]

Measuring elements	***Metrics***
Application KPI Monitoring	Definition of Custom Applications **KPIs**
	Definition of Applications **KPIs Goal** Values
	Presentation of Applications KPIs in **Dashboard**
	Support for change Makers in Charts
Gamification Element Statistics	Support for KPI Goal Markers in Charts
	Gamification **Feedback** Rate
	Distribution Points over Users
	Statistics Of Achievable **Gamification Element**
	Presentation of User Distribution on Gamification
	Presentation of Temporal Gamification Element Statistics
	Analysis of Significant **User Characteristic's**
	Alerting on Violation of **Design Intentions**
Gamification Design Adaptation	Experiment Result Definition
	Experiment Result Analysis
	Direct Design Adaptation
User Groups of Interest	**User Groups** of Interest based on Criteria
	User Groups of Interest based on Cluster Analysis
	Filtering of Overviews by User Groups of Interest
Simulation	**Simulation** based on existing User Behavior Data

This study has shown the absence of a specialized tool to monitor and adapt gamification designs. Field experts have confirmed the use of customized solutions according to the need eventhough these solutions remain costly. Hence, having a common tool for the evaluation of the gamified software quality is needed. The next sections present our contribution to this study.

c) Gamification design and experimental attributes:

After studying the frameworks and platforms of Gamification, identified patterns have to be consolidated and classified in order to get the final list of Gamification attributes. This list will be used in the next steps to establish a characteristics and sub characteristics mapping of the quality model ISO 25010. More details of the obtained results are found below:

Table 2. Gamification attributes

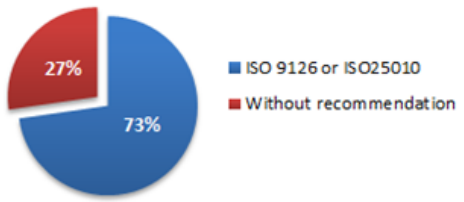
Categories	***Subcategories***
Gamification components	Game element and mechanics (Dashboard, Feedback, Points…)
	Game dynamics
	Meaningful Gamification
Motivation	Intrinsic Motivation
	Extrinsic Motivation
	SDT (self-determination theory)
Engagement	Durability
	Improvement
Process / Design	Analytics / Design Model
	Software Prototype
	Evaluation
	Tool
	User centered
	Simulation
Goal	Business Goal
	Gamification
	Balancing
Profiling	Business profile
	Player types
	User group
	Balancing between player and business profile
Measure	Business
	Gamification
	KPI
	Balancing between Gamification and business measure
Security	Confidentiality
	Ethics

5. Choice of a reference quality model software: ISO 25010

To build a quality software, the use of quality models is necessary. According to ISO / IEC IS 9126-1 [5], a quality model is "the set of characteristics and relationships that serve as the basis for the specification of quality requirements and for evaluation". The main idea of these models is to decompose the quality of software into characteristics (representing the fundamental factors) and sub-characteristics (the sub-factors), while specifying the metrics corresponding to each of them.

Several software quality models have been studied according to their different characteristics, with the aim of selecting the most suitable for the evaluation of the Gamification frameworks among which the following models are found:
McCall model, Boehm quality model, FURPS Quality Model, ISO 9126 standard quality model, IEEE model, Capability Maturity Model Integration (CMMI), Quality model ISO 25010, etc.

Following our literature review, we found numerous articles that compare the existing models, which we examined to select the most suitable for our study. The figure below summarizes the research recommendations in this area:



	ISO 9126	ISO 25010	No specific recommendation
2006	[22]		
2008	[20]		
2009	[14]		
2010	[13] [15]		
2011			[21]
2013	[12] [19]		[16] [23]
2014		[17]	
2016			[18]

Figure 4. Results of recommendations study

Following these studies, the majority of the recommendations were oriented towards the ISO9126 model and its new version 25010, which justifies our choice of the latter. These conclusions have been drawn:

- The ISO9126 model is a generic framework that allows users to develop their own criteria [12].
- The ISO 9126-1 quality model is the most useful as it was built on the basis of an international consensus and agreement of all ISO member countries [12][19] [20]
- It contains the last standardized terminology [17]
- The ISO-9126 model has received input from previous models and set standards to evaluate the quality of the software [17] [20]
- It can be adapted to any type of software product and is oriented towards evaluation and improvement [17]
- The ISO 25010 model is the most complete among the basic models, as it covers 26 of the 28 characteristics [17]
- The ISO model seems to be more complete and with less defects than other models. The most important features of the ISO model are hierarchical structure, evaluation criteria, complete terms and expressions, simple and precise definitions, and a one-to-many relationships between the various layers of the model [26]

As a result, the ISO model has been chosen as a base model and customized to become more suitable for evaluating a particular application domain, which is a gamified software application

6 New quality model for gamified software

After presenting the results of the comparative studies of the software quality models and choosing the ISO 25010 (fig 4) model as a reference model, this section presents the different steps that were followed in the analysis and customization of the characteristics and sub-characteristics of this model.

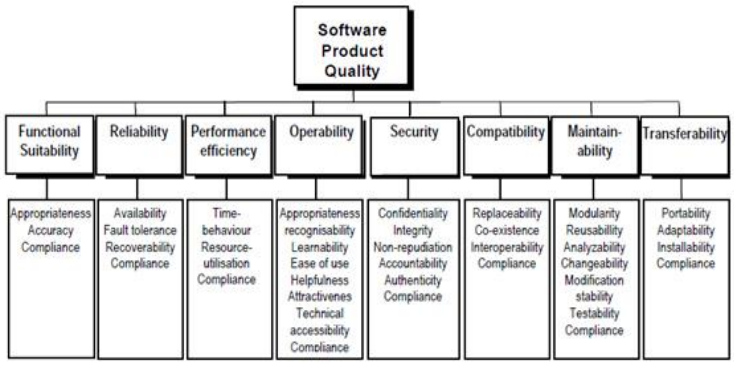


Figure 5. Software Quality Model [ISO/IEC 25010]

Following a detailed analysis of the description of each sub-characteristics of the ISO 25010 model (also called SQUARE); we classified them according to the following 3 statuses (table 2):

Acquired '-': Corresponds to characteristics / sub-characteristics that have no particularity for a gamified product.
Adopted '=': These are the sub-characteristics we have adopted without modifying the measure elements to judge the quality of gamified software.
Modified 'x': Represents the state of the characteristics important to the evaluation of a gamified software, but requiring a modification of content or data...

Table 3. Customized software quality model [ISO/IEC 25010]

Characteristics	Sub- Characteristics	Option
Functional Suitability	Functional completeness Functional correctness Functional appropriateness	x x -
Performance efficiency	Time behaviour Resource utilization Capacity	= = =
Compatibility	Co-existence Interoperability	- -
Usability (Operability)	Appropriateness recognizability Learnability Operability (ease of user) User error protection/Helpfulness User interface aesthetics Accessibility	x x x - x x
Reliability	Maturity Availability Fault tolerance Recoverability	- - - -
Security	Confidentiality Integrity Non-repudiation Accountability Authenticity	- - - - -
Maintainability	Modularity Reusability Analysability Modifiability Testability	- - x x x
Portability	Adaptability Installability Replaceability	- - -

This list of characteristics has been revisited to give an oriented definition of the qualification of the gamification system.

Functional Suitability :

Sub-characteristic	*Description*
Functional completeness	Generally, this must be translated by accounting for and defining the **business objectives** with a projection on the **user's** tasks, while taking into account the particularity of the **player profiles**. This also implies that a **balancing** is ensured between the user's objectives and business objectives, as well as the associated **measures**.
Functional correctness	Through the **KPI application** and indicators, the process must be able to provide the expected result with the expected precision.

Performance Efficiency :

Sub-characteristic	*Description*
Time Behavior	The aim is to ensure the rapidity and availability of information according to the type of **users** and their needs. According to Philipp Herzig [25], the relevant **measures** in this aspect are: - Time to Completion: The time period between the start of user existence and **gamification element** completion; - Time to Assignment: the time period between the start of user existence and its assignment to the **gamification element**. - Time Active: the time period between assignment and completion of the gamification element. Generally, a user completing a **mission** faster than expected could be an indicator of the adjustments needed to design the mission.
Resource utilization	Availability Degree of **tools** needed for **analysis**, **evaluation** or other

Usability :

Sub-characteristic	*Description*
Appropriateness recognizability	Considering the different **player profiles** in the system according to the particularities of each user.
Learnability	It concerns: - Degree of learning quality provided without risking user's **satisfaction**. - Degree of system recognition of the users' level and purpose in order to familiarize them with the application. - The ability of the system to **motivate** and **engage** learners in the learning **process** in order to achieve the specified **quality** and efficiency objectives.
Operability	- Degree of software use in relation to the **user's competence level** (Progress, Purpose, Relatedness, Mastery, Autonomy...) - Degree of model richness with the **game mechanisms** (examples: dashboard, levels,) allowing a fluid use and an easy control of changes. Simplicity must also be encountered

	from the first experience to achieve the desired state, called «Win-state". According to Yu Kai in his Octalysis model: "The first Win-state happens when the user first says, “Wow! This is awesome!”[28]
User interface aesthetics	**Extrinsic** effect: Ergonomics Degree of the user’s interface by implementing the **game mechanisms** (dashboard, level, points, ...) in the user’s interface to ensure a pleasant and satisfactory user’s interaction. **Intrinsic** effect: Degree to which the system allows users (or customer business vision) to quickly **engage** with the application **objectives**
Accessibility	Adaptation Degree of the framework to the **user’s characteristics** and advanced level (**mastery**)

Maintainability :

Sub-characteristic	*Description*
Analysability	This involves assessing the availability degree of the user’s behavior analysis and evaluation, namely: - The availability of data and user’s progress statistics in the **dashboard**, based on **gamification elements** such badges, levels or missions, ... - The application must issue events that inform the gaming solution analysis about relevant user’s properties such as age, areas of interest, personal motivations, functions within an organization, which can help optimize a gamification design for specific target groups within final users. [25] - **Tools** Availability to monitor the achievement of business objectives, analysis of the gamification state, and adaptation of the **gamification design** in case of deviations or changes in the objectives. - The presence of **analysis tools** (query, extraction, ...)
Modifiability	The ability of the system to adapt to changes in order to improve the functionality of the gamified application as users experience it.
Testability	Degree of effectiveness and efficiency testing of criteria to assess user’s actions, behaviors and achievement of business objectives. The testability is not limited to this aspect, it is also necessary to several parameters: - Particularty of user profiles, for example, Bartle's Four Player Types (Achievers, Explorers, Socializers, Killers) - Mastery level (Progress, Purpose, Relatedness, Mastery, Autonomy, ..) - The test phase (Discovery, Onboarding, Scaffolding and Endgame)

7 Conclusion and Future Work

This study focuses on the advancement of research in the gamification concept, especially for the software engineering field. We noted a gap between the process and the product. Indeed, the majority of theoretical frameworks are limited to the general aspects of design rather than other phases. In return, several gamified softwares are found but do not share their frameworks and development processes in full, which raises the need to produce a new framework with a process that covers all phases of a software lifecycle. The new model will be the result of a comparative study of existing models.

Our work stands as a preparatory phase of this comparative study. In this article, we have targeted the existing software quality models, among which we have selected the ISO 25010 quality model that seems the most suitable to our needs. This model has been revised to adapt to the Gamification concept.

In future work, we intend to use this ISO 25010 Gamified quality model to evaluate the existing Gamification frameworks in order to propose a new and more complete framework.

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