Game-Balance Simulation as a Tool for the Evaluation of Systematically Designed Gamification Strategies

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Abstract

The development of successful gamification strategies requires a consistent, systematic approach including context analysis, ideation, and mechanic design. Finally, in the evaluation phase, it is verified what impact the gamification strategies actually have in order to make adjustments before implementation in the target context. The evaluation is mainly based on elaborate empirical methods. An objective, non-empirical evaluation method does not exist yet. Video game balancing can be tested by digital simulation tools (e.g., machinations.io) that illustrate game element relationships in flowcharts. This research demonstrates an approach to modeling gamification strategies in game balance simulation tools to make better assessments of the probability of success by combining results from the relevant literature and current research. Conclusions and implications for future research for the simulation of gamification strategies with game balancing tools are derived from a theoretical model implementation.

Keywords 1

Gamification, Game Balancing, Gamification Evaluation, Gamification Simulation, Machinations

1. Introduction

Gamification is a modern approach to increasing motivation by using "game design elements in non-game contexts" [1]. The goal of gamification is usually to extrinsically and intrinsically increase people's motivation to perform certain actions, behaviors, or decisions by incorporating elements from video games into real-world situations. Gamification projects in most cases follow a structured design process to support successful development as described in *How to design gamification? A method for engineering gamified software* by Morschheuser et al [2].

Klock et al. point out in *Tailored gamification: a review of literature*, that "tailoring the game elements according to the users' profile is a way to improve their experience while interacting with a gamified system" and hence, offers a significant improvement to system design [3].

An important and also challenging aspect of gamification design is the evaluation of the developed strategies, especially in terms of "correct tailoring" for a given use-case. Morscheuser et al. defined gamification design principles based on literature research and assigned them to the design phases. The design principle for the evaluation phase reads:

"Define and use metrics for the evaluation and monitoring of the success, as well as the psychological and behavioral effects of a gamification approach." [2]

As concluded by Klock et al. in most gamification design studies use empirical evaluation methods for evaluation such as surveys and questionnaires. [3]

Besides the inherent disadvantages, such as the correspondence principle and the problem of

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basic statements, empirical methods are usually very time-and effort-consuming. Additionally, through biases due to study participants and investigator and the influence of external variables as well as the dependency on the boundary conditions the results of empirical evaluations may be questionable in terms of validity and objectivity. [4]

In terms of gamification evaluation with empirical methods, this means that e.g. mapping of different user types in a representative distribution to the real use-case is difficult as well as the realistic representation of the use-case without external variables during play-testing. Hence, an objective, non-empirical evaluation approach would add significant value to the development of gamification strategies.

Game balancing describes the adjustment of parameters, scenarios, and behaviors in video games to strike a balance between frustration due to overchallenge or boredom due to underchallenge [5]. Machinations.io is a browser-based game balancing tool. Using flowcharts, video game contexts can be visualized and actively simulated. The goal is to optimize games in terms of user experience and to identify potential problems and errors, such as game scenes that cannot be handled by players [6].

This paper investigates the principal suitability of machinations.io as a simulation tool for gamification strategy projects. An exploratory study examines the relationships between user types, game elements, motivation, and the completion of desired actions. Implications for future simulations of gamification strategies are pointed out.

2. Theoretical Background

2.1. Gamification

The term gamification first appeared in 2002 in a paper by management consultant Nick Pelling, and over time it has gained more and more attention in many fields. In 2011, the first scientific conference on this topic was held [7]. Gamification is a relatively young approach that started in the field of software development. In the meantime, gamification methods are already being used successfully in many application areas [8,9,10]. The concept of gamification attempts to use the potential of video games in a meaningful and targeted way. The goal is to increase people's motivation by offering new incentives to increase interest in activities and make overcoming challenges more attractive. By systematically designing gamification strategies, the positive motivational potential is tapped and desired actions are triggered. Since gamification aims to influence user behavior, desired actions define the goal of a gamification project [11]. The theoretical background is provided by approaches from motivational psychology, such as Csikszentmihalyi's flow theory, which describes the optimal state of concentration between boredom due to underchallenge and stress due to overchallenge [12]. Deci and Ryan's self-determination theory describes the basic drives of human action represented by autonomy, competence, and relatedness [13].

2.2. Player and User Types

Player Types (in the gaming context) or User Types (for gamification) provide a characterization of the users regarding their attitude or core motivation to use a respective context.

Bartle set the foundation for this concept in 1996 with the Four Player Types [14]. He describes four different player types that typically occur in video games and are characterized by different primary play styles. The four player types *Killer, Explorer, Achiever, and Socialiser* can be represented in a coordinate system with the axes Players – World and Acting – Interacting [15].

To translate the player types in video games to user types in gamification, Marczewski combined Bartle's original four player types with Deci and Ryan's self-determination theory to create the user types HEXAD [16]. Marczewski describes the six different user types that have different underlying motivations. The intrinsically motivated types are “Achiever”, “Socialiser”, “Philanthropist”, and ”Free Spirit“. They are motivated by relatedness, autonomy, mastery, and purpose. The other two types, motivated by extrinsic rewards and change, are “Disruptor” and “Player”. The user types HEXAD model enables the classification of people in gamified applications. Through a survey on his website, Marczewski performed a distribution of people into user types HEXAD [17]. The results are: “Philanthropists” 27%, “Free Spirits” 22%, “Achiever” 17%, “Socialiser” 16%, “Player” 15% and “Disrupter” 3%. However, this list only represents the dominant user types of the test participants. For a detailed description, Marczewski presents further subtypes of the user types and also proposes a user type evolution. In addition, Marczewski defines mixed user types. Thus, people can be assigned to several user types by their answers in the test.

2.3. Game elements

Game elements form the basic repertoire for gamification design. Game elements are elements derived from video games, which are used there for a specific purpose. Classic examples are points, rankings, and badges. These elements have already been categorized in various frameworks and described as solution-neutrally as possible for use in gamification projects. Based on a previous analysis in a gamification project, suitable game elements can be selected and then designed for the individual use case.

The MDA (Mechanics – Dynamics – Aesthetics) framework of Hunicke et al. [18] describes the interactions between players and the system in game design. The Mechanics represent the particular components of the game, Dynamics are the behavior of the mechanics depending on the player inputs and Aesthetics describe the emotional reaction of the player to the system. While players perceive a game from the aesthetics side, the game developers focus on the mechanics first. For gamification applications, the MDA framework provides an orientation on how game elements shall be designed to influence the behavior of users in a gamified system.

Marczewski's "Periodic Table of Game elements" consists of 52 game elements assigned to the six user types HEXAD and two general categories [16].

2.4. Tailored Gamification

The consideration of different user types and the adaptive design of gamification strategies, called *tailored gamification*, is a current topic in scientific research. Tailored gamification offers significant advantages compared to one-fits-all gamification solutions [19] but at the same time increases the complexity of the developed strategies and consequently impedes empirical evaluation.

Santos et al. have also shown that it is possible to assign specific game elements to user types [20]. Rodrigues et al. conclude in their literature review on personalized gamification that users with specific player types are more likely to enjoy specific game elements [19]. Several studies observe the relationship in tailored gamification between user types and game elements as mentioned by Hallifax et al. [21] but also offer heterogenous results due to limitation to specific areas (e.g. health or education), the use of different user type frameworks, and different abstraction levels of game elements and motivation. Hallifax et al. discover numerical results for relations between user types (among three user typology frameworks) and twelve game elements, which are mainly not significant, nevertheless, the authors propose to use the user types HEXAD in future studies. Tondello et al. [22] describe the relationships of game elements (gameful design elements) to the user types HEXAD in an exploratory factor analysis. In an online survey, participants were analyzed in terms of their user type and then asked about their preferences for specific game design elements. They find significant correlations between 49 game elements and the user types HEXAD by using eight cluster components.

2.5. Game Balancing

Game balancing describes a continuous process in video game development to optimize the game experience. On the one hand, the balance within and between game elements is considered to identify possible dead ends and faulty interactions. For example, the points required for level advancement might be too high, blocking game progress or leading to player frustration. On the other hand, the balance between players must always be adjusted. For example, if one character class is clearly superior to the others in an online role-playing game, players will exclusively play that class to succeed. This inevitably leads to frustration and boredom among players, and thus a lower probability of success for the game. Therefore, even after a video game is released, so-called balance patches are often implemented to balance the gaming experience. This is particularly necessary for games that regularly provide new content for players, as the influence of the new elements can only be tested under appropriate test conditions. However, necessary changes often emerge only when the dynamics of the game evolve through a large number of players [5].

Machinations.io is a browser-based platform for designing, balancing, and simulating game systems (see fig. 1). It allows to represent arbitrary game systems in an interactive diagram, set parameters, define elements and their relationships to each other, and visualize how the systems work. This allows potential balancing problems to be identified and fixed before video games are released and without much programming effort [6].

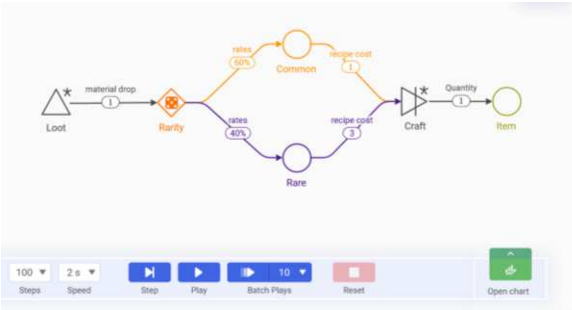

Figure 1: Example flowchart on machinations [6]

Several basic tools are available that can be combined to create complex logics. A source creates elements according to determinable conditions, a pool collects elements at intermediate points, and a gate can distribute elements. Resource connections route elements, while state connections represent conditions. Registers can be used to mathematically compute relationships. The end condition terminates the run.

3. Research Goal

The explanations above show that the evaluation of developed gamification strategies has so far been carried out using exemplary implementations in test environments with subsequent empirical evaluation. Empirical methods are usually time-consuming while the validity of the results is highly dependent on the boundary conditions. An objective, solution-neutral and effort-reducing way to simulate gamification strategies does not exist yet. Game balancing tools like machinations.io are not used because they are not designed for this use case.
By performing an explorative study in machinations.io the research goal of *evaluating gamification strategies in game balance simulation tools* will be addressed.

The approach consists of four main steps:

1. Defining the necessary elements to map motivational contexts in game balance tools based on a literature analysis.
2. Linking the identified elements with relationships from scientific findings to a theoretical model.
3. Implementation of the theoretical model in machinations.io as an explorative study
4. Basic evaluation of the implementation by an exemplary execution of the model

4. Modeling gamification

4.1. Elements definition

To find the necessary elements to be simulated, literature reviews on gamification frameworks are considered. The literature analysis at "web of science" and "google scholar" for open access review articles with "gamification" and "framework" in the title offers three results. Two of them did not fit the target of the analysis.

In their literature review on gamification frameworks, Mora et al. [23] identified the MDA framework [18] as the most referenced one. The MDA framework defines Mechanics (or **game elements**), Dynamics (or the interaction of the **user** with the system or **context**), and Aesthetics (emotional response of the user or **motivation**). The authors also mention a clear win condition (or **desired action**) that has to be fulfilled by the player. To address the current stage of research regarding tailored gamification, the user taxonomy **user types** HEXAD of Marczewksi [16] is added to the list of simulation elements as suggested by Hallifax et al. [21].

4.2. Relationship definition

The relationships between the elements are defined following the explanations in the MDA [18] and user types HEXAD framework [16]. The users in the gamified context are divided into different user types according to their characteristics and the user spectrum of the context to be gamified. The user types have an average baseline motivation value to perform a desired action, which is defined by the goal of the gamification project. This motivation is influenced positively, negatively, or not by game elements. Game elements have an individual impact on different user types. The adapted motivation influences the probability to perform the desired action.

To complete the theoretical model, the following questions need to be answered:

- What is the percentage distribution of users among the user types HEXAD?
- What is the relationship between a change in motivation due to game elements and user types?
- How does a change in motivation affect the decision to perform the desired action?

The distribution of users among user types depends on the individual use case of the respective gamification project and cannot be answered generally. Therefore, this distribution is taken as given. In this study, the survey results of Marczewski [17] are used because they have a high participation rate and do not relate to a specific context (see chapter "Player and User Types").

The correlation of whether a motivational change is triggered by a gamification element among user types is numerically extracted from Tondello et al. [22] as the study provides the broadest data on different game elements and significant correlations to the user types HEXAD. Tondello et al. describe the correlations of 49 game elements and the user types HEXAD to eight psychological components (Socialization, Assistance, Immersion, Risk/Reward, Customization, Progression, Altruism, and Incentive). For example, the game design element “Guilds/Teams“ is defined by a socialization value of .668 and an altruism value of -.430. The user type “Free Spirit“ shows correlations of .003 to socialization and .149 to altruism. The Socialization and Altruism values are each multiplied and then added to the direct correlation factor. In this example, the “Guilds/Teams“ element has an impact of -.062 (or -6.2%) on the ”Free Spirit“ user type. The steps of this exemplary calculation are illustrated in figure 2.

A negative influence on motivation does not automatically lead to a decision against the desired action, a logical connection must be established between the change in motivation and the decision for the desired action. Since there is no concrete scientific knowledge about this relationship yet, a statistical distribution is considered here. The basic distribution is modeled as a Gaussian distribution on a scale from 0 to 100 percent around the predefined motivational baseline value with a sigma of 10 percent. Thus, if the motivational baseline for the desired action is 50%, users have a probability between 10% to 90% of performing the desired action, with a sigma 1 interval between 40% and 60%, a sigma 2 interval between 30% and 70%, and so on. If a user is positively or negatively influenced by a gamification element, this is distributed only on the respective positive or negative half of the Gaussian distribution. For example, a “Free Spirit“ user is negatively influenced by the “Guilds/Teams“ element. The baseline value for taking the desired action is set to 50%, so the user has a 68.2% chance of being distributed on the Sigma1 interval. This results in a 50-40% chance of performing the desired action.

After this step, the users' performed desired actions are summed up and put into a relative ratio to the total number of users. The difference between this factor and the average baseline motivation value gives the percentage increase (or decrease) in the performed desired actions due to the influence of the game elements.

Components	User Type „Free Sprit“	Game Element „Guilds / Teams“	Calculation
Socialization	.003	.668	.003 * .668 = **.002**
Assistance	.126		
Immersion	.406		
Risk/Reward	.120		
Customization	.117		
Progression	.013		
Altruism	.149	-.430	.149 * (-.430) = **-.064**
Incentive	.030		
Correlation Factor Free Spirit x Guilds / Teams			.002 + (-.064) = **-.062**

Figure 2: Exemplary calculation of the correlation factor for the “Free Spirit“ user type and the “Guilds/Teams“ game element

The theoretical model and an example user journey are shown in figure 3. This exemplary user gets assigned to user type 1 (with a motivational baseline value of 50%), gets influenced negatively by game element 1, and hence assigned to the negative half of the Gaussian distribution. With a probability of 28% the user takes the sigma_2 interval and thus has a

30% chance to take the desired action, which he finally does not.

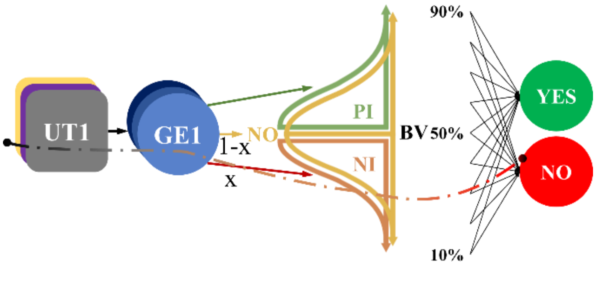

Figure 3: Theoretical model and example user journey (pointed line) (UT = user type, GE= Game Element, x= calculated influence of GE1 on UT1 based on [22], PI= positive influenced users, NI=negative influenced users, NO= not influenced users, BV= motivational baseline value (here 50%))

4.3. Model implementation

The previously described theoretical model is now implemented with machinations.io. The complete model is attached in Appendix 1.

The simulation model includes five sub-steps:

1. Distribution of users to user types.
2. Calculation of motivation direction influence through game elements
3. Calculation of motivation change distribution
4. Calculation of the decisions for the desired action
5. Calculation of final evaluation factors

4.3.1. Distribution to user types

This step defines the characteristics of the users in the context of the simulation. As this is highly dependent on the context, a user analysis is necessary to determine the real existing distribution. For simulation purposes, the distribution of Marczewski's survey is taken here [17] (see chapter Player and User Types).

The distribution is realized in the simulation by a random gate with probabilities of the paths according to Marczewskis survey results (see fig.4).

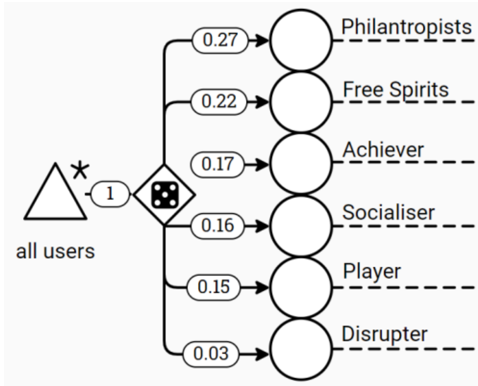

Figure 4: Distribution of users to user types acc. to the HEXAD model with the results of Marczewski [17]

4.3.2. Impact of game elements

This step determines whether the game elements have a positive, neutral, or negative impact on the user's motivation concerning their user type. In this particular example, the user type "Free Spirit" is considered. The two game elements chosen are "Guilds/Teams" with a calculated value of -6.21% (see chapter relationship definition) and "Unlockable or Rare Content" with a value of 16.18%. The user type is implemented as a source representing the users. Each user interacts with the two game elements implemented as random gates. The probabilities of the paths to positive, neutral, or negative influence refer to the calculated values based on Tondello et al. [22]. The motivational changes are each represented by a pool (see fig.5). Since a user generates two simulation elements, the pools must be normalized later in the simulation.

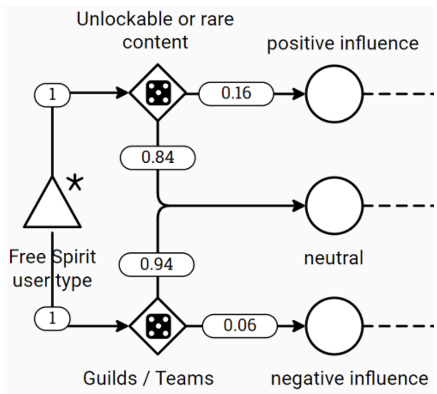

Figure 5: Relationships between User Types, Game elements, and Motivation Change

4.3.3. Motivational change

This step defines how much the motivation changes based on a Gaussian distribution.

Users who are positively influenced by the game elements are distributed on the positive half of a Gaussian distribution, while negatively influenced users are placed in a negative half. Neutrally influenced users are randomly distributed positively and negatively in the Gaussian distribution, which is realized by a 50/50 chance of negative or positive distribution. Each simulation element that represents a motivational change in the pools triggers a source that distributes the elements to a Gaussian distribution via a random gate (see fig.6).

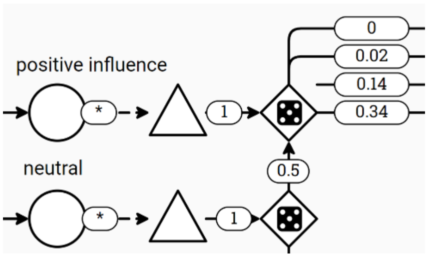

Figure 6: Calculation of motivational change distribution via Gaussian distribution

4.3.4. Decisions for desired actions

This step determines how the change in motivation affects the user's decision to perform the desired action. A scale from 0 to 100% is used for this purpose, representing the probability of performing the desired action. For each user type, a context-dependent baseline value can be preset, which can be manually adjusted during the simulation using an active slider. The sigma value of the Gaussian distribution is fixed at 10%. If a user is distributed to the respective interval, he will be assigned to the middle value. The formulas in the simulation diagram also take into account that the Gaussian distribution does not generate probabilities above 100% and below 0% (see fig.7). Thus, a user with positive influence from a gamification element has a 68% chance of being distributed into the interval +sigma*1, with an assigned probability of taking the desired action of base value + 5%. In this example, with a base value of 50%, this results in a 68% chance of taking the desired action with a 55% probability, a 28% chance of achieving the 65% probability, a 4% chance for 75%, and a 0.04% chance for 85%.

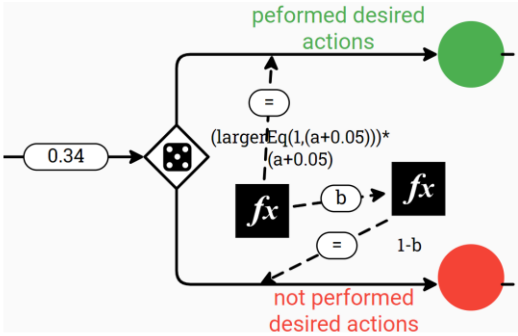

Figure 7: Calculation of decision for desired actions in the sigma_1 interval on the positive half of the Gaussian distribution

4.3.5. Factor calculation

Finally, the calculated values are combined and analyzed. With different combinations from the pools of performed and not performed desired actions, the success rates of the game elements for the user types can be calculated (see fig.8)

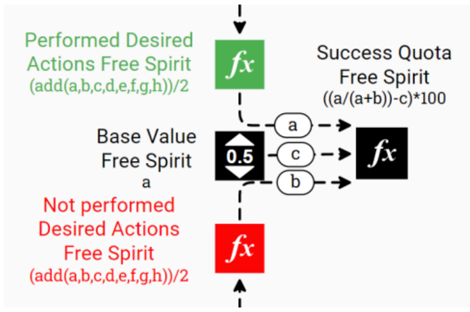

Figure 8: Calculation of evaluation factors

In the present exemplary implementation for the user type “Free Spirit“ with a base value of 50% and the game elements “Guilds/Teams“ and “Unlockable or Rare Content”, the simulated success rate leads to generally more performed desired actions compared to the baseline value.

The success rate of all user types is simulated 50 times with 600 steps each simulation. The data indicates a combined success rate of about 5% compared to the average baseline value of all user types with a standard derivation of 2.1%. The results of machinations.io can be plotted in an execution chart and exported (see. Fig. 9).

5. Discussion and future research

The possibility to simulate gamification strategy results with game balance simulation tools can possibly extend existing research regarding tailored gamification. While empiric studies (e.g. [3,20,22,24] show the influence of

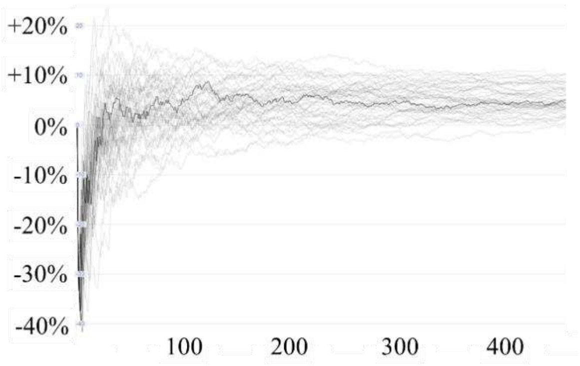

Figure 9: Execution chart from machinations.io (x-axis: performed simulation steps, y-axis: improvement compared to baseline value)

game elements on user types, the presented approach relates these results to the performance of the desired action and puts them into the bigger context of a gamification strategy with combined game elements, a specific user type distribution, and context influence.

The results of the simulation model presented in chapter 4.3.5 have to be interpreted carefully, as an exact transfer to real gamification application can possibly result in other outcomes. The goal of simulating gamification strategies for evaluation purposes is not yet to accurately predict the effects of game elements on the performance of the desired action, but to provide objective guidance on how various game elements might affect a given context. The number of identified simulation objects provides a basis for simulation purposes, but can certainly be expanded. In particular, the elements representing individual context influence need to be explored and analyzed in more detail in future research to create the possibility of better consideration in simulation contexts.

Tondello et al. [22] give a direct way to generate numerical relationships between user types and game elements, but this has to be considered as an approximation since people on average do not correspond to only one user type [17], and also user types may change over time [25].

The Gaussian distribution on the extent of motivation change is an approximation, as research findings in this area are lacking. As soon as findings are available, they need to be implemented in the simulation model to describe this relationship more realistically.

In general, the validity of the simulation model must be verified in comparison to empirical results to ensure that the simulations represent reality within the necessary limits, otherwise divergent results between the simulation and the real implementation of gamification strategies may occur. Extending the simulation with more scientific findings will possibly enable a more realistic outcome and hence, a more consistent evaluation method for gamification strategies.

Hence, future research should focus on empirical evaluation of the model to ensure validity, the extension with more scientific findings, and the implementation of the context impact.

6. Conclusion

In conclusion, this study shows that in general with some limitations, the simulation of the influence of game elements on motivation and thus the decision for or against the desired actions is possible. Gamification strategies can be simulated in game balance tools, yet there is a lot of potential to extend this research, especially in the empirical validation of the model.

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