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Personalized Gamification: A Model for Play Data Profiling

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Abstract

This paper proposes model for introducing personalized game-design elements in a gamification system. The model is based on user-centred design, human values theory, and gamification design framework. The proposed model promotes the idea of a baseline game component that is meant to acquire online, real-time data about the cognitive and emotional state of the individual, and based on the collected data to adjust the gamified system to the state of the user. This framework, which we name Play Data Profiling (PDP), describes a model of collecting and processing data before, during and after the actual use of the gamified application in order to optimize the subsequent user experience and outcome. Implications and future work are discussed.

1. Introduction

Gamification is defined as the use of game elements in non-gaming systems to improve user experience and user engagement [7]. The first design ideas of using fun and game for computer-aided learning belonged to Malone in 1980s (see [16,17]). The design of gamification involves introducing game-design elements into the software development of the target system. Because of its potential benefits, gamification has attracted attention to both researchers and developers and has been explored in many use contexts such as education and use of libraries, usability testing, personal health informatics, risk management, and enterprise information systems (see e.g., [1,3, 6,18,19,27]). However, the design of a successful gamified-system is still challenging. In particular, two challenges exist: 1) to design a gamified system that motivates people to use the system, and 2) to design a gamified system whose usage produces the expected outcomes. Motivation and fulfilling goals are in strong relationships with individual differences. It was shown already in the 70s that personality traits of the users should be considered when designing information systems [2]. Since then, the design informed by personality and human values has been proposed by many scholars (see e.g., [21,22]). Moreover, it has been shown that personality traits affect the interaction with and the response to different technological systems as well as the adoption of technology (see e.g., [9,12,23,24]).

In this paper, we propose a model for introducing personalized game-design elements in a gamification system. The novelty of this model is that it promotes the idea of a baseline game component that is meant to acquire online, real-time data about the cognitive and emotional state of the individual, and based on the collected data to adjust the game (gamified application) to the state of the user. The role of the baseline game component is to assess the personality and the current state of the user. This information will be processed and classified into predefined player (user) profiles, which will determine the type of game interface and mechanics to be loaded in the current game session[1]. This type of game component would ensure an optimal user experience and outcome. The proposed framework draws upon established design theories and framework such as the user-center design [11] and gamification design framework [31], as well as on the human values theory [30] and research on personality and moods, emotions and affective states.

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[1] In our model, gamified system and game are used interchangeably, as well as users and players. In the model, we refer to the gamified application or system by the more generic term "game" as we adopt the conceptualization that a gamified system is built with the assumption that the system will be perceived by users in the same way a game is perceived by players by invoking similar psychological experiences as in gameplay (see [10]). Thus, in our conceptualization, a gamified application or system has the characteristics of a game, but it is used in a non-game context such as work or education to stimulate user engagement. Therefore, we also refer to users as players.

The paper is structured as follows. Section 2 describes the theoretical background and related work. Section 3 describes the proposed framework. Section 4 discusses the implications and future work.

2 Theoretical Background

2.1 User-centred and gamification design

User-centred design (UCD) is an approach used throughout the entire system development cycle to ensure the developed system fulfils the usability requirements [11]. This means that the developed system matches the user profile, goals, and needs (see e.g., ISO 9241-210 [11]). The UCD process is iterative and incremental; different designed solutions are created and tested [26] by employing usability knowledge and methods. The design activities specified in ISO 9241-210 are: 1) understand and specify organizational requirements; 2) understand and specify context of use; 3) produce design solutions; 4) evaluate design against requirements.

Usability is very important for the game to be well received and successful [8] in terms of satisfaction, efficiency, and effectiveness [5]. In addition, user experience (UX) is a dimension of user satisfaction that should be taken into account when designing and evaluating games. User experience is defined as being the sum of an individual's "perceptions and responses that result from the use or anticipated use of a product, system, or service" [11]. UX is thus associated with the internal state of the user when interacting with a product in different stages of use (before, during, and after) and it is believed to affect the overall satisfaction with the product (see e.g., [5]).

UCD approach is applied successfully in various contexts of use of information systems; however, in the game development, the application of UCD is more challenging because the entertaining nature of the games makes more difficult and complex to design and assess the fun of the game and the user engagement.

In the gamification context, there are several gamification frameworks proposed in the literature that address the user dimensions and propose design recommendations to ensure the fun in the game (e.g., [7,31]). Deterding et al. [7] identify as the most effective game design elements that elicit user engagement the so-called points, badges, and leaderboards; these elements appear in most of the games and can be associated with intrinsic and extrinsic motivation (see [13]). Werbach and Hunter [31] approach the user by guiding the development to define the business goal, target behaviors, and players' characteristics and types. Nevertheless, in the gamification domain, the gamified solution has to be both engaging and fit to the organizational purpose; therefore an integration of UCD and a gamification framework would ensure that usability and UX requirements are fulfilled by using a range of methods and techniques centered around usability and UX at each step in the gamification process (see [25]).

2.2 Personality, values and emotions

Both the UCD and the gamification design models stress the importance of understanding and defining the user characteristics. In addition, the UCD provides the methodology to ensure that these characteristics are well understood and taken into account in the design, thus, complementing the gamification design framework by providing actionable guidelines to ensure satisfactory usability and UX. One of the guidelines refers to defining all relevant dimensions of players in the context of use and describing the players in terms of personas (i.e., user representatives) (see [4]). Personality, psychology, and behavioral phenomena should be addressed when profiling the players [7] and these profiles should be taken into account in the design.

However, studies focusing on individual differences define the individual characteristics in several ways, for example, by demographics (e.g., age, gender, education), personality type (e.g., the Big Five personality types [9,12]), behavioral-disposition traits (approach and withdrawal motivation [23,24]), human values [29]. Of particular interest is the human values theory by Schwartz [30] which posits that "(1) values are concepts or beliefs, (2) pertain to desirable end states or behaviors, (3) transcend specific situations, (4) guide selection or evaluation of behavior and events, and (5) are ordered by relative importance." The human values can be therefore seen as individual characteristics that guide and motivate people in their life, and examples of such value types are self-direction, hedonism, and achievement. This theory has been also used in system design to cluster users by motivational values (see e.g., [29]). Moreover, recent research shows that mood, cognitive and emotional states affect the user experience and responses to

interaction with a system, product or service. However, satisfaction and affective states are complex concepts to define and measure as they are multidimensional and time-dependent [28]. Scherer [28] classifies the affective states based on two dimensions (duration and intensity) into several constructs such as: personality traits, attitudes, interpersonal stances, mood and emotions. Emotions themselves can be defined and categorized in several ways such as discrete (anger, happiness, etc.), bi-dimensional (along the valence and arousal axes) (see [14]).

Given the diversity of users and user dimensions, the profiling of players and the clustering of the players by meaningful profile characteristics is important for the success of the game according to UCD and gamification principles (see [11,31]). However, the clusters/profiles are not necessarily stable in time, but they change over time (i.e., one player can be categorized according to his/her characteristics and behavior as belonging to one profile cluster at a certain time, but later his/her profile can change). Moreover, there are individual characteristics that are inherently fluctuating such as mood, tiredness, and emotions. Table 1 illustrates different types of individual characteristics classified by the degree of variation along time. As they influence and are being influenced by the gameplay, system developers should take them into account when developing a game or a gamified system. In the next section, we propose a model of gamification system that takes into account this variation and transition of player profiles.

Table 1: Individual characteristics of players by degree of variation along time

Small or no variation	**Moderate variation**	**High variation**
Gender	Attitudes	Mood
Nationality	Values	Emotions
Personality traits	Socio-cultural	Cognitive load
Education level	Experience	Psychophysiological

3 Play Data Profiling (PDP) Model

UCD and gamification design models focus on system development, namely they provide guidelines to design, development, and evaluation of a gamified system, software or service that fulfills the needs of the players and organization. For this purpose, one widely used method in UCD is to identify and define persona profiles based on individual characteristics such as personality, demographics, roles, and needs. However, these profiles identified during the system development cover only partially the characteristics of the users, namely the ones that are relatively stable such as age, gender, and personality traits. On the other hand, users have different moods, values, and psychophysiological states (e.g., high level of stress as indicated by heart rate or electrodermal activity) that are fluctuating over a certain period of time and which influence the user experience.

Therefore, we propose that in addition to profiling the target users during the development cycle, a gamified system should be built in such a way that it collects on-line, real-time play data based on which profiling continues also after the system development. Thus, the proposed Play Data Profiling (PDP) model states that the gamification elements can be adapted and personalized based on the interaction and/or psychophysiological data collected before, during and after each gameplay session in order to fit best to the current state of the player (user). The assessment of the player (user) or game session at a particular time may determine a transition from one profile cluster to another or an update in the player profile, which in turn may determine a change in the game interface and gameplay. Thus, this model proposes that a gamification system is composed of a set of alternative designs corresponding to different profiles and player (user) states. These alternative designs are pre-built based on the UCD guidelines and gamification design principles. During the play, on-line evaluations of the game sessions and the player are performed using built-in game analytics which provide new information for the profiles and the current state of the player. The play data profiling is then used to personalize the gameplay and the game interface.

PDP model presents a gamification system as consisting of three parts: 1) the pre-play data profiling component, 2) gameplay, and 3) post-game analysis (see Figure 1).

The first component is meant to provide a baseline interaction with the system of a short duration (e.g., 3 min) during which the player is assessed; for the player it acts like a “warm-up” session before the actual play. For example, different stimuli related to the business objectives of the gamified system and to the overall categorization of the player persona profile categories are presented, while the system collects and analyzes different interaction events (e.g., mouse movements,

choices, time taken) and, if possible, psychophysiological measures (eye tracking, heart rate, skin conductance, etc.) to measure stress level, emotional states, and cognitive load. During and after this "warm-up" session, a machine learning based pre-play data profiler evaluates the user interaction events and the psychophysiological measurements in order to identify the best player persona profile category for this individual player. The system uses this categorization to personalize and tailor the gamification elements (target behaviors, activity loops, elements of fun, and tools) in the gamified system in next step in order to maximize the player engagement, fun, and fulfillment of the business objectives.

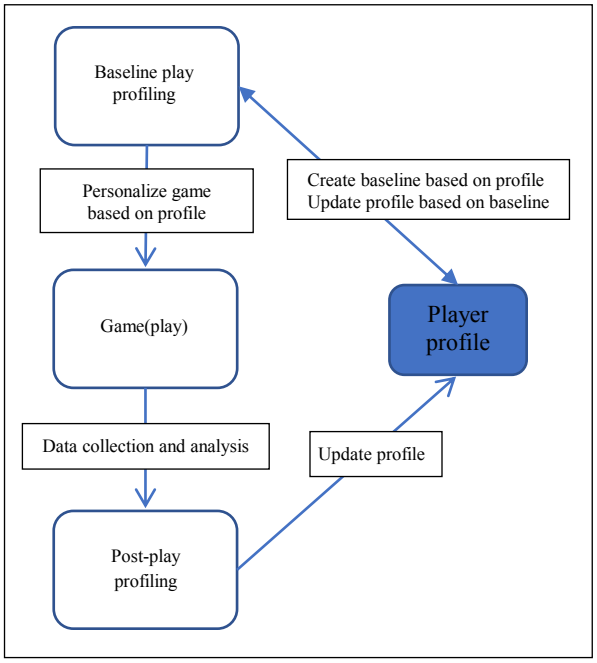

Figure 1: Play Data Profiling model. The baseline "warm-up" component collects and analyses pre-play data, based on which a personalized game is provided. Player profile is also updated with the new information. The gameplay component collects the data during the actual game. The post-play component uses the game play data to update the profile.

Every time a baseline is created at the beginning of a game session, some of the information is taken from the player profile (i.e., the player profile acts like a schema or template on which pre-play data are contrasted and integrated). After the baseline is created, the new information obtained during pre-play session is fed back into the player profile, and thus some updates in the player profile are possible and enabled by the system (thus, the system is constantly learning the player profile and the baseline is created not only based on the real-time data, but also on historical data and the player profile by using machine learning techniques). To build this component both the UCD and gamification design principles are employed; the assessment of the profile at this stage is automatic, but it has to include knowledge of the users, their needs, and characteristics, as well as behavioral data (such as user selections) collected during the baseline.

The second component in the PDP model represents the actual gameplay or system use, personalized so it matches the player profile and the current state evaluated by the first component. While the user interacts with the gamified system, the system collects logs of interaction events (and psychophysiological measures) until the play session ends. This component also utilizes elements from both the UCD and gamification design principles; the designers of the system must identify the business objectives, define the target behaviors, activity loops, elements of fun, and the available tools employing the UCD process and methods.

The third component in the PDP model represents a machine-learning component for processing the play data of the user, his/her current mood, values, emotional and cognitive states and the success of the gamification. Were the business objectives and target behaviors successfully fulfilled? Was the gameplay session fun to the user? These assessments as well as the identified play patterns are fed back into the profiling of the player, and the update is used in further sessions of the same player or other players.

Along with the conceptual model of collecting and processing play data in different stages of use of a gamified system (Figure 1), we illustrate the model from the perspectives of a designer and of a machine learning developer. Figure 2 describes the PDP model from the designer perspective. The UCD process and methods, and the gamification design principles are employed to define meaningful profiles, to create alternative game designs (interface, mechanics, gameplay elements) to match the business objectives and the player profiles, and to define criteria for the post-play evaluation and profiling. Here designers employ various methods, techniques, and tools in order to collect and analyze the data such as heuristics and

usability engineering [20], psychophysiological measurements [15], and other user testing methods.

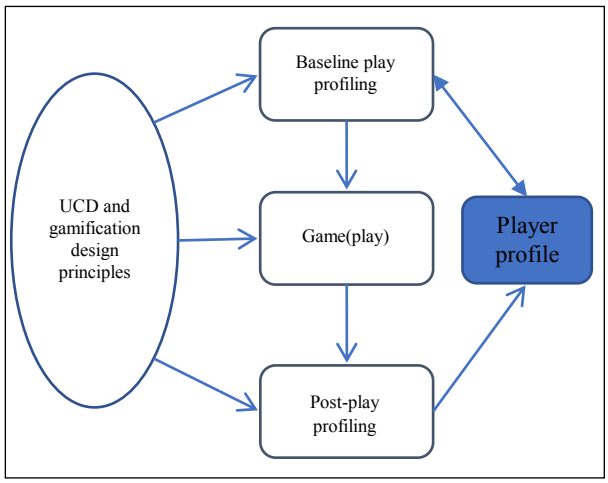

Figure 2: Play Data Profiling model from the designer/developer perspective.

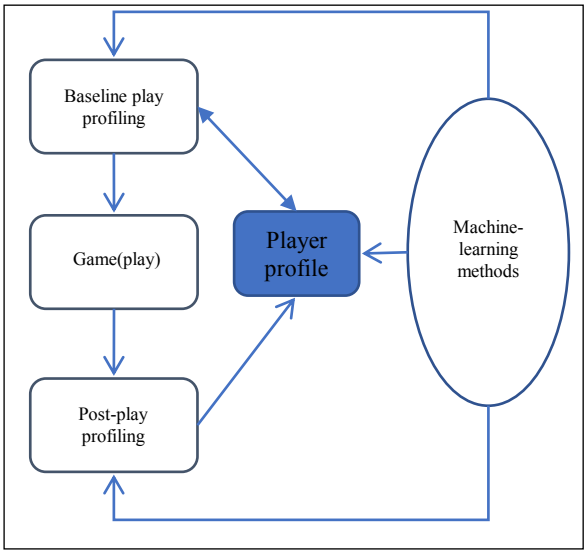

Figure 3: Play Data Profiling model from the machine-learning perspective.

Figure 3 describes the PDP model from the machine-learning perspective. As the amount of the gathered during the baseline and actual play is very big, and the processing needs are in real-time, advanced machine-learning algorithms and methods should be developed and utilized in order to obtain timely information about the current player and categorize it in a meaningful profile. Moreover, at post-play stage the huge amount of log data (as well as physiological data) requires also machine-learning methods to make sense of the data and update the profile database with new information about the game session, player, and fulfilled objectives.

As in different stages of game development and game play different data are collected, Table 2 illustrates different types of data collected during the gamification cycle. The table is not exhaustive and not all categories are compulsory (for example, psychophysiological measurements are not always possible to obtain during the actual game play). During the design and development, the range of data acquisition methods and protocols (e.g., experiments, tests, observations, surveys, expert evaluations, etc.) is limited only by the available resources; on the other hand, during baseline and gameplay the acquisition should be carefully implemented so not to disrupt the play experience. Inquiry methods can also be employed if the questions are well integrated into the game interface (for example, at the end of the game session one question can be "Are you satisfied with the game session today?", or depending on the game domain and business objective a more concrete, context-specific question or a question to describe the mood of the player).

Table 2: Gamification cycle and data acquisition

Game Design and Development (1)	**Baseline and Game play (2)**
Observational data	User inputs (e.g., mouse clicks, scrolling)
Inquiry data (questionnaires, surveys, focus groups)	User choices or selections
Heuristics	Time
User testing using various methods (see column 2)	Psychophysiological measurements including eye tracking

4 Discussion

This paper proposed a play data profiling model for data-driven personalization of gamified systems. The model is based on the user-centred design model, human values theory, and gamification design framework. The proposed model introduces the concept of a baseline game component that acquires online,

real-time data about the cognitive and emotional state of the individual and based on the collected data, the system adjusts the game interface and elements to the current state of the player. This model, named Play Data Profiling (PDP), describes a process of collecting and processing data before, during and after the actual play in order to optimize the subsequent user experience and the outcome from both the user and the business perspectives.

4.1 Implications

The PDP model has implications to research and practice. First, it provides the researchers and practitioners a model of personalized gamified system that utilizes behavioral, physiological, psychological, environmental (context of use, business objectives), and social data as well as machine learning (data mining, statistics, and AI) techniques to provide tailored game elements to users with different characteristics. This model can be empirically tested and further refined and expanded. Second, it provides researchers and practitioners an iterative model for continuous player persona profiling before, during and after gameplay. Third, the gamified systems personalized through PDP model have an impact on users, since it can be assumed that personalizing the gameplay experience to suit the current player profile and psychophysiological state of the user will make each gameplay experience more engaging, fun, positive, and productive for the user. Therefore, designing gamified systems using PDP model can also help the system to fulfill its business objectives, since they will have a positive impact on target behaviors.

However, the play data acquisition, analysis, and profiling for personalizing the gamification carries some significant ethical implications and challenges that the designers have to take into account. The users should be made aware that their interaction with the system and/or their psychophysiological state will be logged in particular ways for data acquisition, analysis, and player profiling. Ideally, the user should be given a choice regarding the degree of personalization they are comfortable with. This degree of voluntary personalization could range from no personalization at all, to full personalization, and various degrees of privacy in between. In case of user not giving his/her consent to any personalization or data collection, the gamified system should have a pre-defined generic player profile, which should be the best compromise between different player profiles identified during the design phase.

4.2 Future Work

In the future, the PDP model might be empirically evaluated through an evaluation prototype such as a proof-of-concept system. This prototype could be a simple, small-scale gamified system, for example a website or app with educational goals. To implement the model in a real system requires managing the following challenges: 1) availability of computational resources for data storage and processing, 2) data security, 3) data complexity, 4) design complexity. However, these complexities can be tackled by employing an incremental and iterative approach which starts with a simple system and adds new features over time. The idea is to design the gamified system in a way that it allows the system to adapt as it learns the users' behaviors and profiles.

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