A participatory design framework for the gamification of rehabilitation systems

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ABSTRACT

In recent years games and game technology have been used quite widely to investigate if they can help make rehabilitation more engaging for users. The underlying hypothesis is that the motivating qualities of games may be harnessed and embedded into a game-based rehabilitation system to improve the quality of user participation. In this paper we present the PACT framework which has been created to guide the design of gamified rehabilitation systems; placing emphasis on people, aesthetics, context, and technology from the beginning of a design and development process. We discuss the evolution of PACT from our previous GAMER framework, which was used to develop a range of games for upper arm stroke rehabilitation with natural user interfaces. GAMER was established to guide the design of rehabilitation games from the viewpoint of a designer, whereas with PACT greater emphasis has been placed on an inclusive design process. We provide a detailed work flow illustration for the use of PACT in the development of rehabilitation systems and provide examples of practical design and analysis tools that improve the quality of workflow in PACT.

1. INTRODUCTION

PACT (People, Aesthetics, Context, and Technology) may be described as a participatory design framework for the gamification of rehabilitation systems. Inclusive participation from the beginning of a rehabilitation design process has been raised as an increasingly important experimental methodology (Gooberman-Hill et al, 2013). Influence from games in the design of engaging rehabilitation software has also received a lot of recent attention (McNeill et al, 2012). Though only a few papers make explicit reference to gamification, e.g. (López-Rodríguez and García-Linares, 2013), there is often an implicit application of simple gamification techniques in the design of bespoke rehabilitation. The focus is often on inclusion of fun user feedback for the completion of tasks, with points, badges, high score tables, and leader boards being typical design patterns used. There is a danger, however, in taking too narrow a focus in the application of gamification to the design of systems. If the design focuses too much on task completion and rewards then there may be an over emphasis on extrinsic motivation, which has less impact on long term behaviour and attitude change. Behavioural change is central to the goals of a well-designed rehabilitation system (Michie et al, 2011). There are several definitions for gamification that vary depending on context but most focused on engagement or motivation (Deterding et al, 2013). For example, the influential company Badgeville states that "gamification is the concept of applying game-design thinking to non-game applications to make them more fun and engaging" (Gamification Wiki 2014). We prefer a broader definition in its application to rehabilitation software; considering gamification as the application of game elements and metaphors, game design patterns, or game technology to the design of systems that can positively influence behaviour, and improve motivation and engagement of people with non-game tasks and processes. We therefore view gamification as taking any influence from games and applying it to a non-game context. In this way a serious game, game-based learning, simple reward based feedback, and a walk in a virtual world can all be thought of as subsumed by the gamification label. In the PACT framework we endorse a system of gamification that can account for variation in motivational factors amongst different individuals and we illustrate this with a workflow diagram.

2. GAMER FRAMEWORK

The GAMER framework (Fig 1.) was developed to guide the design of rehabilitation games (see Burke 2011) for expanded version) that help motivate people to engage with their required exercise regime in the home. It has

been successfully utilised in the creation of several webcam (Burke et al, 2008) and augmented reality games (Burke et al, 2010) for upper arm stoke rehabilitation, the latter licensed to US robotics company Myomo in 2011. GAMER was developed after extensive investigation of game design theory from leading game designers and in collaboration with physiotherapy researchers to map therapy goals to tailored, motivating physical gameplay. Our approach was similar to Goude et al. (2007) who also used the comprehensive collection of game design patterns by Björk and Holopainen (2005) as a central design inspiration. GAMER maps keys game design or gameplay elements that are have been identified as being specifically relevant to physical gameplay via a natural user interface to core therapy goals. The framework can be used to aid a designer in creating varying forms of gameplay that emphasises different aspects of therapy by choosing a suitable subset of game design elements/patterns in the design and directing of the choice of interaction hardware. Burke (2011) provides detailed worked examples on how we evaluated GAMER through the design of several rehabilitation games over two case studies.

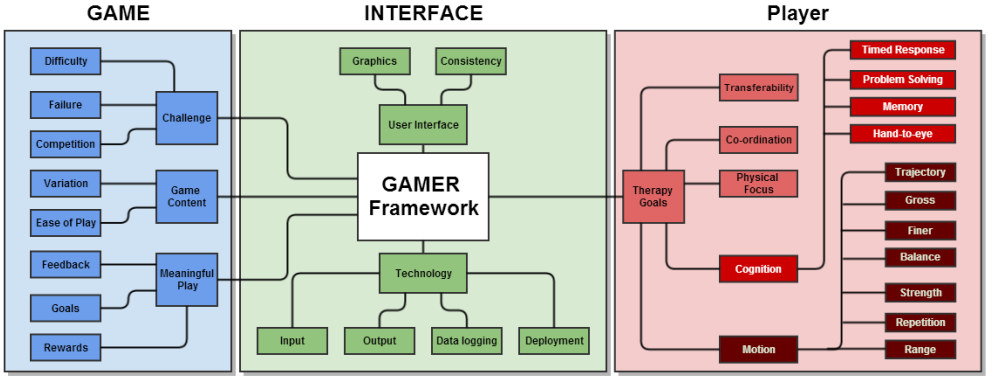

Figure 1. The *GAMER framework is designed to guide the design of rehabilitation games.*

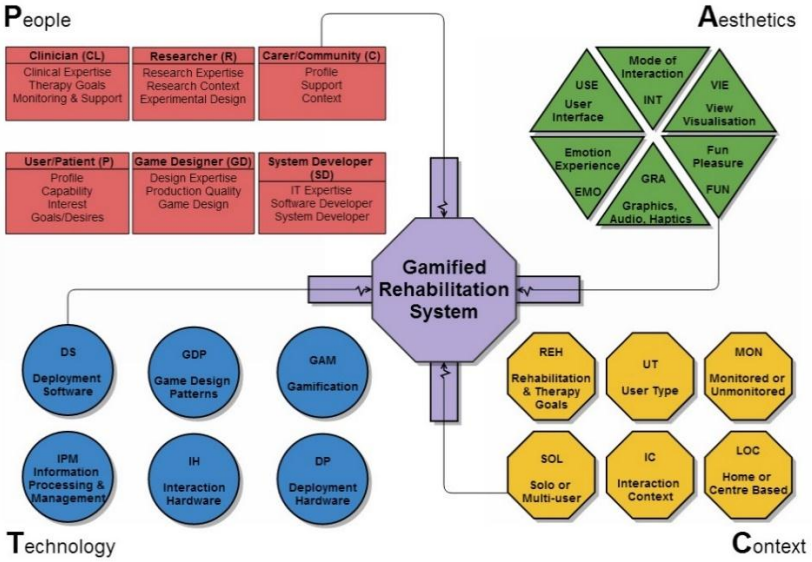

Figure 2. *PACT is a participatory design framework for the gamification of rehabilitation systems.*

3. PACT GAMIFICATION FRAMEWORK

GAMER demonstrated the potential of a structured approach in the design of usable, engaging, and effective rehabilitation games. It is particularly useful in mapping therapy goals to physical gameplay elements and embedding positive reinforcement feedback aesthetics. Our PACT framework evolved from GAMER to increase our focus on stakeholder involvement and place a stronger emphasis on personal motivation of users. The PACT framework (Fig. 2) has four dimensions, People, Aesthetics, Technology, and Context, which form the focus for the design of gamified rehabilitation systems. Unlike GAMER, PACT has an implicit focus on participatory design and involvement with all of the relevant stakeholders from the beginning of a rehabilitation design process. The emphasis on gamification within the PACT framework has a number of significant advances. Firstly, the outcome of a gamification process may not be an obvious game but may simply result in the addition of fun feedback (e.g. points and badges) to a non-game context (e.g. physical movements round the home), could recommend the use of gaming hardware in a non-game context (e.g. digital painting), or the use of game worlds

to immerse and inspire (e.g. walks with friends in virtual game worlds). Secondly, new advanced gamification approaches can help tailor system design to account for diversity in motivation between different people. The emphasis on behavioural change correlates with other framework designs in the research area (Michie et al, 2011).

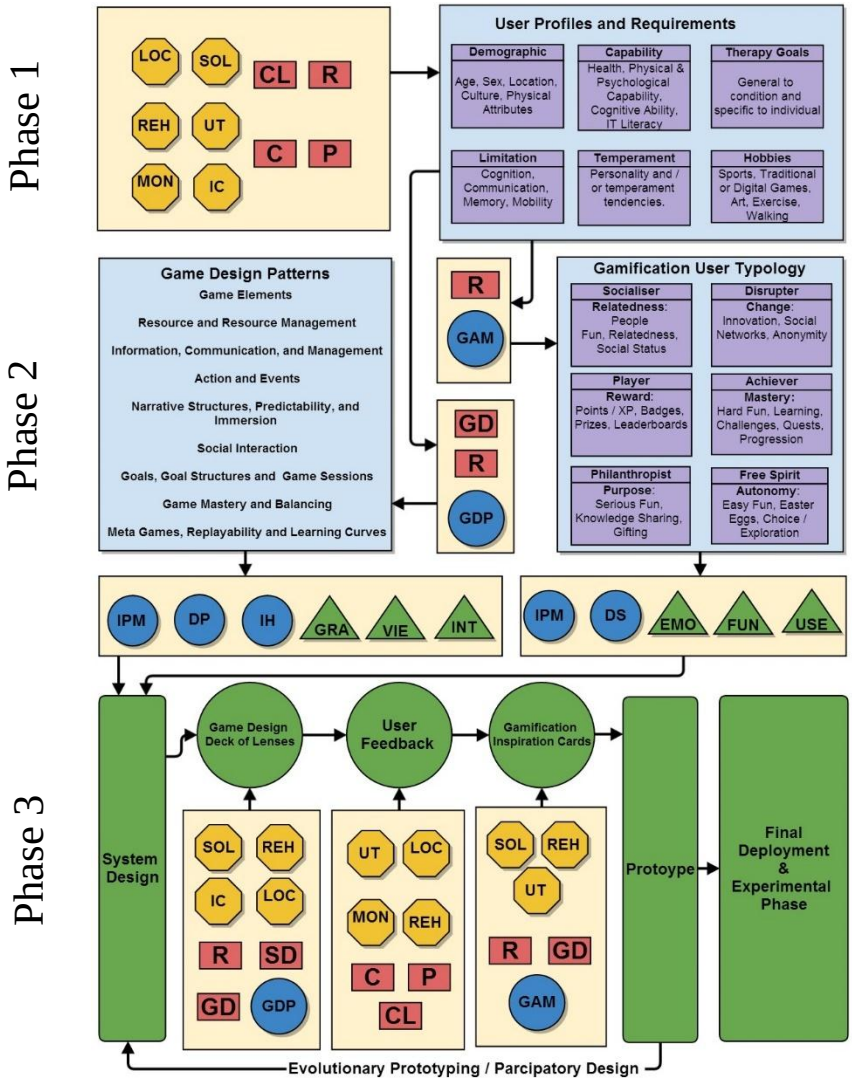

Figure 3. *Sample PACT Rehabilitation System Design Workflow (see Fig. 2 for symbol meaning).*

Figure 3 provides a typical workflow diagram for the implementation of the PACT framework in practice. This resembles the practice that we undertook in the design of our recent upper arm stroke rehabilitation simulations with the Leap Motion controller (Charles et al, 2013). We can split the PACT design process into three phases: Phase 1 is essentially a requirements gathering phase and involves a dialog between clinicians, researchers, users/patients and other stakeholders from the community to establish the basis for system design founded on therapy goals and on specific user and carer needs. Capability of the target group will be accounted for at this stage and temperament models and personal interest of users may be taken into account in order to tailor the design more effectively. Phase 2 is the core design phase and in our new model includes both an underpinning of game design and gamification. In the work flow example shown in Figure 3 we utilise the set of comprehensive game design patterns from Goude et al. (2007) and list the key pattern group headings (NB other references may also be used). The gamification technique that we propose is based on Marczewski's Hexad gamification typology (Marczewski, 2014). This model has its origins in Bartle's player types (Bartle, 1996) and RAMP intrinsic motivation model. Effective gamification can engage individuals by tapping into particular aspects of their intrinsic motivational psychology. The RAMP model outlines four key motivational drivers for people: Relatedness, Autonomy, Mastery, and Purpose. Relatedness equates to sociability, autonomy is about facilitating choice and creativity, mastery relates to the provision of opportunities to learn and improve, and purpose recognises that people are more motivated when they understand the context for their efforts. The Hexad suggests six basic types of user, each being motivated by different intrinisc or extrinsic motivational priorities. The outcome from phase 2 is a system design developed in partnership with key stakeholders. Phase 3 is

essentially an evolutionary protyping phase where system software is created and integrated with required hardware. In the workflow example provided we suggest a structured approach for analysis of the design based on the evolving system prototypes. As a 1st stage of evaluation process we suggest rigorous and creative way evaluation of the design by a research and development team using a tool such as Schell's game design lenses to focus on core design topics (Schell, 2008). A 2nd evalution stage involves play and usability testing by users and other stakeholders using techniques developed during our GAMER experiments (or similar). During a 3rd stage of the system evaluation, the gamification system is analysed and redesigned on the basis of user feedback. A structured method such as the use of Marczewski's gamification cards can aid this process. The eventual outcome from phase 3 will be a completed gamified rehabilitation system. The development of the PACT workflow was informed by the recent development of an upper arm rehabilitation systems using a virtual reality based approach and Leap Motion depth sensing controllers for a natural user interface (Charles et al, 2013). Physiotherapy and computing researchers, clinical physiotherapists and occupational therapists from the Northern Ireland Regional Acquired Brain Injury Unit (RABIU) at Musgrave Hospital in Belfast (n=8), and game designers/developers from a commercial company (SilverFish Studios) were engaged in the appropriate phases of PACT (though not patients in this initial proof of concept process). The outcome was very positive and the software is currently under development (PACT phase 3) for use in clinical trials.

4. CONCLUSIONS

In this paper we introduced our PACT framework; a participatory design oriented process for gamifying rehabilitation systems. To explain its use in practice we provided a detailed work flow diagram that included specific suggestions for analysis and design with key stakeholders. Early and structured ongoing involvement of key stakeholders within the system design process is central to PACT. A core recommendation for the realisation of PACT is the separate consideration of the influence of game design patterns and gamification best practices for rehabilitation system design. This allows us to separate functional aspects of game design from motivational qualities of game interaction and can enhance the quality of design. A novel approach in our PACT work flow illustration is the use of Marczewski's gamification Hexad to help identify ways in which different people can be motivated to participate. PACT has been developed ahead of a new three year project which seeks to design and develop motivating game-based exercise systems for people affected by Multiple Sclerosis.

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