Jurnal Teknologi

Full paper

Including Gamification Techniques in the Design of TANGO: H Platform

Carina S. González-González[a*], Pedro Toledo-Delgado[a], Miguel Padrón[b], Elena Santos[a], Mariana Cairos[a]

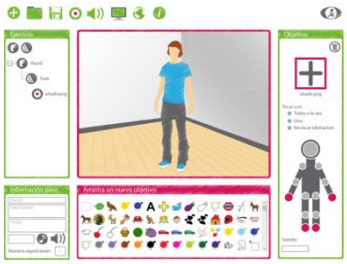
[a]*Department of Engineering Systems and Automation and Architecture and Computer Technology. University of La Laguna. La Laguna. Tenerife. España*
[b]*Institute of Renewable Technology and Energy(ITER).Tenerife. España*

*Corresponding author: cjgonza@ull.es

Article history

Received :11 September 2012
Received in revised form :
21 February 2013
Accepted :15 April 2013

Graphical abstract



Abstract

This paper presents the design approach of TANGO:H (Tangible Goals: Health): a platform for the creation of physical and cognitive rehabilitation exercises. This platform is adaptable to the characteristics of the population it is intended: children hospitalized and in home care. Also, it is highly configurable and customizable, thanks to exercises editor: TANGO:H Designer. This feature allows health professionals and educators to create game-like exercises, adapted to the specific needs of end users and to the context in which the intervention will take place. Note that TANGO:H was designed for the recreational, educational and rehabilitation use for children at hospital. So, in order to improve the users' experience with the platform and their engagement, several Gamification techniques has been included. This paper focused on the technical and gamification requirements of the design of TANGO:H.

Keywords: Gamification techniques; cognitive and physical rehabilitation; Kinect; openNI; videogames

© 2013 Penerbit UTM Press. All rights reserved.

1.0 INTRODUCTION

The hospital classrooms (AH) provide educational services to students hospitalized during the period of compulsory education [1]. The types of disease affecting these students are varied, but stand out the oncological, orthopedic, respiratory, diabetes and surgery. The time of admission to hospital may be of short duration (up to 5 days), medium duration (6-20 days) and long duration (over 21 days) and may affect the process of socialization and formation of the child. An average of 210 children a year is treated in the seven Canary hospital classrooms. Collaboration and discussion with clinicians (Pediatrics, Nursing and Physiotherapy) on the needs of this hospitalized population concluded that it was feasible to develop playful tools based on technology and a scenario to boost and strengthen the physical and motor activity of hospitalized children and adolescents. Note that this is a facet of their development so far unattended, but still there are several researches tools for the rehabilitation purposes [2, 3]. These reasons have motivated the creation of the platform TANGO:H (Tangible Goals: Health), whose design and development has two main objectives:

- Design and develop an open platform accessible and highly configurable to enable the creation, customization and adaptation of exercises and activities according to the specific characteristics of each user and user group.
- Design a social gaming platform, educational and of rehabilitation that follows the principles of game play and gamification to maximize motivation and customer satisfaction in its execution.

Below we will analyze the requirements that we have followed in the design and development of the platform, we describe the principles of game play and gamification and how we have applied it in our application. The paper is structured as follows. In section two, a sound description of the gamification techniques is included. Afterwards, in section three, a description of the application TANGO H, is included, followed by the explanation of the gamification process followed in section four. Latterly, the description of the implementation details is included in section five. Finally, conclusions and future work are discussed in section six.

2.0 GAMIFICATION

Relating to the "addictive" or "engagement" component of games, we can found the "gamification" concept [4]. Essentially, gamification tries to apply the mechanics of the games in other

settings, such as the educational environment. This concept is not directly related to game design, but seeks to engage the user through small doses of challenges and rewards in order to get that the user perform certain actions in different environments.

Gamification works to satisfy some of the most fundamental human desires: recognition and reward, status, achievement, competition & collaboration, self-expression, and altruism. People are hungry for these things both in their everyday world and online [5]. Gamification taps directly into this.

The game mechanics can be of different types, such as: a) behavioral (focused on human behavior and the human psyche), b) feedback (related with the feedback loop in the game mechanic) and c) progression (used to structure and stretches the accumulation of meaningful skills). Following, we present a proposal of different suggested game mechanics to gamify environments:

- *Collection:* it exploits the human characteristic of "collector", all are or have been collectors of something: books, records, pictures, movies, etc.
- *Points*: it is the most used mechanical, in real life we handle sports scores, grades in school, etc.. We reward or punish through the points given or removed, respectively. Points are a running numerical value for a single action given or a combination of actions.
- *Comparisons and classifications (leaderboards):* it exploits the social component, the effort is compared with other users and / or other types of classifications (global, local, etc..). Leaderboards give users the feeling of "fame" and "status." They also give users the chance to compete and compare with other members or players.
- *Levels:* the levels are related to the user experience or level of expertise (ex-pert users, beginners, etc..). Karate belts, job titles, and frequent flyer programs are just some of the examples. They are to shorthand indicator of status in a community and show that you should be afforded respect for your accomplishments.
- *Status:* status is the ranking or level of a player, related to the scores obtained by users, users are motivated to achieve a high status.
- *Feedback*: people are used to receiving feedback on their actions, it is important to reward positively and provide information to the user about his condition, the environment, and their achievements. For example, showing the progression in which the success is granularity displayed and measured through the process of completing tasks. Or giving rewards to motivate users: points, badges, trophies, virtual items, un-lockable content, digital goods, etc.
- *Achievements*: achievements are a virtual or physical representation of having accomplished something, usually considered "locked" until the user have met the series of tasks that are required to "unlock" the achievement, for example virtual coins, medals or badges.
- *Epic meaning:* Players will be highly motivated if they believe they are working to achieve something great, something awe-inspiring, something bigger than themselves. Examples of this mechanic applied to education could be, the fight to save the planet while they are learning about the environmental care.

There are other game mechanics that can be used for gamification activities, such as: *time* (the players have some limited time to perform a task), *exploration* (players have to explore and discover things that will surprise them), *challenges* between/among users (players can challenge each other and compete for the achievement of objectives, objects, medals, etc.).

It is also important to have other people with whom to compete, collaborate and compare accomplishments. As a general rule, humans want to interact and compete with others. In the social game, the objectives can be competitive or collaborative. When you get users to compete and collaborate as part of something bigger, it in-creases the stakes, adds another level of accountability and is a dynamic motivator. So, in team games must be considered separately the mechanics that influencing the team (win projects, group scores, etc.) as well as the mechanic is that influencing the individual (motivation, positive reinforcement, etc.). In a best-practice implementation, a user's individual achievement should be rolled up under the group or team's success and highlighted in inter and intra group leaderboards and news feeds.

The best way to approach this is with a standard ranking system. Once you have identified the actions for environment, system or activity, you will want to rank them in order of value. Start with the least valuable action and give it a factor of '1.' Working from there, assign relative values to everything else.

So, you can use different kinds of point for different purposes and activities, for example: basic points (usually earned by participation and spendable on virtual or physical goods), experience points (earned by participation, constantly increasing and the point total is never deducted, not spendable), premium points (only for some special action, spendable on "premium" virtual or physical goods). Once they reach a set number of points, they progress on to the next designated level. Alternatively, another option is a hybrid approach, mixing points and tasks to allow the users to progress. Badges should tie directly into the goals and to what users care about and are proud of. They also encourage exploration of your site, even mastery. Badges can also be used to encourage users to take a specific action. Some badges can be "aspirational," requiring certain prerequisites such as achieving a certain level or owning another badge or virtual good.

Another option is to use the time to reward students based on the made activities, such as:

- *Every time*: every time that participating in the forum, the student earns 10 points.
- *After X times*: after 10 participations, the student gets a trophy.
- *Score higher than X:* score 90 or more on the quiz, and receive 100 points.
- *Time limited*: the clock is ticking! Now or never…

In the next section we present the technical design of TANGO:H platform, and then in section 4 describe how these game mechanics have been applied to design the engagement in the system.

■3.0 TANGO:H

TANGO:H is an application aimed to physical rehabilitation and cognitive training of the minors in situations of illness. It is also a tool for health promotion, where through social games and physical education patients can learn, exercise and interact with others [6]. It is also a tool for professionals (therapists, educators,

and psychologists) can create exercises adapted to the particular needs of each patient or user groups and monitor their evolution. The power of TANGO:H lies in its capacity to generate exercises, i.e. it is not a static platform in which exercises or games are fully defined and integrated, but also allows the implementation of these through an editor that makes this task simple. The program is capable of interpret and execute the exercises previously created by the professional in the editor TANGO:H Designer (Tangible Goals: Health Designer). The interface for the end user, is an active video game, where the patient performs the exercises previously created as a game, interacting with the system through body movements and gestures. The combination between editor and game modules allows the creation of a variety of exercises, personalized and adapted to the characteristic of the patients.
The application shows a simple graphical interface to guide how to select and play the available exercises. As a summary, the main options available are:

- Selecting or creating new users and groups of users.
- Selecting and importing exercise definitions.
- Playing in single or multiplayer mode, sequentially or simultaneously, either collaboratively or competitively.
- Saving and loading information gathered during the game play.

In order to fully understand the framework and elements of the exercises, it is necessary to define a set of concepts. These concepts are the ingredients in which the interaction with the applications is based.

a) *Contact points*: They represent fixed points of the human anatomy. These points are the only ones that application uses to compute the contact with the *target*. Currently the system implements thirteen contact points. (Figure 1).
b) *Virtual Skeleton*: Oversimplified representation of the user body, which continuously follows its movements. The skeleton gives feedback to the user from the tracking the system is doing of his body posture.
c) *Target*: Are elements situated at a fixed position on the virtual environment around the user. These elements are to be reached with one, or many, of the *contact points* controlled by the user body. The targets are represented by images, or regions of the screen, with associated predefined properties:
    - *Set of Contact Points*: The contact points with which the target interacts.
    - *Sound*: The acoustic feedback played when a contact point reaches the target.
    - *Color*: Gives information to the user about which point of contact should reach the target, representing both parts, using the same color.

Based on the above mentioned elements the exercise behavior can be defined, in the following way:

- *Behaviour:* The association of Targets and a set of Contact Points leads to different ways of interaction that should be specified on each case. These possible behaviors are:
- *All at the same time:* All Contact Points on the set should reach simultaneously the target.
- *Only one:* At least one of the Contact Points of the set should reach the target.
- *Distractor:* The target is presented on screen but the user is not expected to interact with it, so no contact points are defined for it. Its only purpose is to make harder to the user to focus on the really interactive targets.
- *Phase:* It is defined as an association of targets. The user should to reach all the targets in the set to go through the phase. The timings in which the targets of the phase should be reached are defined among the following options:
- *Synchronously:* The user should reach all targets at the same time.
- *Asynchronously:* The user should reach all targets but the order it is not restricted, nor if it is done one at a time or simultaneously.

A set of phases is defined as a "step". In order to complete a step, the user should go through all phases that it contains. Depending on the ordering in which the phases should be tacked, a step is said to operate in one of the following modes:

- *Sequentially*: The phases should be solved in the specified order.
- *Random:* The user may solve the different phases, in any order.

Additionally, a step can be defined to be repeated any number of times. This property is called repetition. Sound can be associated with the repetitions, in such a way the user gets feedback whenever a new repetition starts.

Finally, a set of steps, each of which with a certain number of repetitions, define an exercise. Each of the steps of the exercise should be played sequentially, in the order in which they are designed. To summarize, to complete an exercise, the user has to complete: All repetitions of steps in the exercise (sequentially), all phases on each step (sequentially or randomly), and all targets on each phase (synchronously or asynchronously).
The exercises will be displayed on screen "step-by-step", all targets belonging to a step will be shown on the game screen simultaneously. Once all step phases have been successfully completed, all targets will be replaced by the targets of the following step.

Using the established logic, the system classifies exercises in three different types: *physical*, *cognitive* and *free.*
Each exercise class is considered and evaluated differently at execution time.

In the *physical exercises*, the professional desires the user to perform a series of specific movements, making him to reach certain targets with one or more contact points. A large number of visual hints are required in order to communicate to the user the next movement to perform as intuitively as possible. The chosen method to indicate the user the next movement was to match the target and the points of contact highlighting them with the same colour. Furthermore, this exercise class requires a sequential structure that will allow the therapist to orchestrate the exercise at editing.

Moreover, with *cognitive exercises*, the educator is interested in avoiding visual hints that can give away the next target to be reached. Thus, for this exercise class, a set of targets will be presented making the user to engage in a cognitive task such as relate the sound of a cat with its visual representation (matching). Through the use of sound hints, the user will know the next target without making it too obvious. Cognitive tasks do not required a pre-establish order to reach the targets.
In addition, the "*free configuration*" exercise type was added. This class allows the professional to create exercises on the editor ignoring any type of consideration established by the two previous types.

Additionally, TANGO:H allows the user to choose playing in single or multiplayer mode. In *single mode*, the exercise is

completed with the interaction from only one player, disregarding the exercise category, physical, cognitive or free.

In *multiplayer mode* two persons can play sequentially or simultaneously, either competitively or collaboratively. To do so, the body tracking of two users simultaneously, is supported. Furthermore, there are defined two different behaviors for the multiplayer modes. In exercises defined to be played in *sequentially*, users should take turns to complete the exercises. Both users should finish on each turn exercises of the same complexity. During *simultaneous* multiplayer mode, both players interact with the system at the same time. The interaction could be defined to be *collaborative*, so users should cooperate to reach all targets (Figure 2). As an example, an exercise could be defined in such a way the users should couple the targets according to some criteria. Each user should reach one of the targets of the pair they want to establish. At the end of the exercise both users would share the same punctuation; Nevertheless, the multiplayer exercises may also be defined as *competitive*, making users compete to achieve the maximum punctuation while the reach the targets.

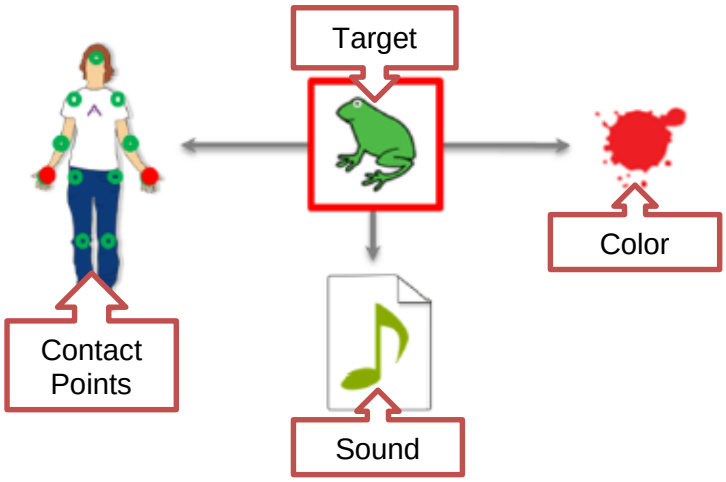


Figure 1 Basic Elements of TANGO:H

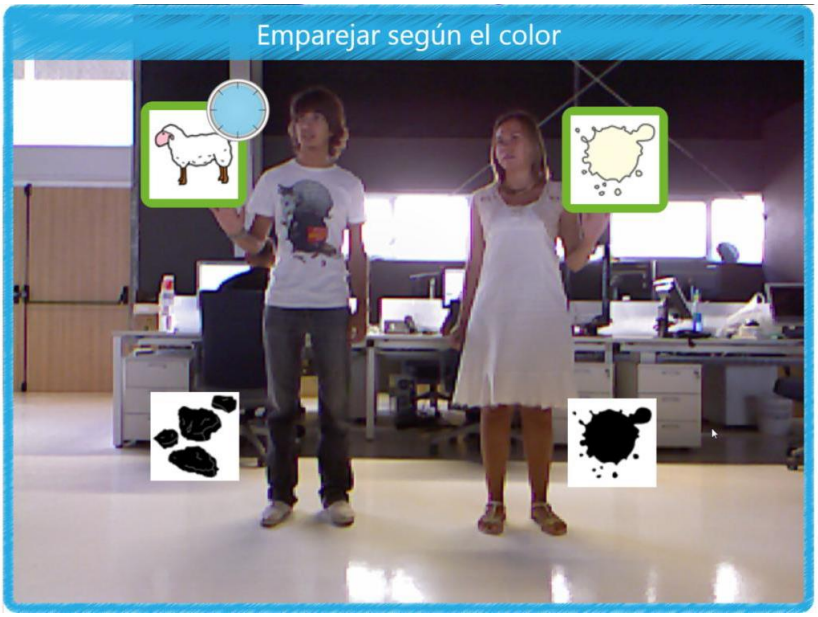


Figure 2 Collaborative Mode: The players cooperate simultaneously during the exercise to reach the targets

4.0 GAMIFICATION IN TANGO:H

After the technical design of the solution described below, other aspects regarding the engagement were designed. The main objective was now making the final solution attractive to the users it is designed for. As mentioned in section two, different techniques, already described in the literature, are known to be useful to get more user friendly and children appealing game-like applications. Nevertheless, the challenge is to appropriately include the mechanism into the specific design of TANGO H. Table 2a and 2b show the gaming elements implemented.

Table 2a Gaming elements

Elements	Description
Points	It is the most used mechanical, in real life we handle sports scores, grades in school, etc. We reward or punish through the points given or removed, respectively. Points are a running numerical value for a single action given or a combination of actions. In TANGO-H user can get points for each exercise performed depending on the amount of the objectives achieved and the time spent to reach them. Each one of the exercises has a maximum score directly related to the solutions that the user must found during exercise. The score will be different depending on the game mode the user are in: -In sequential type (single or multiplayer): A score for the single user. -In simultaneous multiplayer competitive mode: Two scores, one per user. -In simultaneous multiplayer collaborative mode: A single score for the two users.
Leader boards	It exploits the social component; the effort is compared with other users and / or other types of classifications (global, local, etc.). Leader boards give users the feeling of "fame" and "status." They also give users the chance to compete and compare with other members or players. This component matching and classification is exploited through different game modes and can display the leader boards in single or group. In competitive mode can also be seen the leader boards at the level of the classification exercise.
Status	Status is the ranking or level of a player, related to the scores obtained by users, users are motivated to achieve a high status.
Feedbacks	People are used to receiving feedback on their actions, it is important to reward positively and provide information to the user about his condition, the environment, and their achievements. For example, showing the progression in which the success is granularity displayed and measured through the process of completing tasks. Or giving rewards to motivate users: points, badges, trophies, virtual items, unlock able content, digital goods, etc. **Real time scoring** The score is a real-time feature of TANGO:H that allows users to know at all times what is being evaluated for the exercise. The score is shown in the bottom centre of the screen. **Success effect** Another feature of the platform TANGO:H is the success effect that provides a positive feedback to players. This effect is shown when the users end a phase of the exercise that they are performing. The 'success effect' is represented as a shaded glow that fills the screen in blue and gives the user a visual positive signal.
Achievements	Achievements are a virtual or physical representation of having Accomplished something, usually considered "locked" until the user have met the series of tasks are required to That "unlock" the achievement, for example virtual coins, medals or badges. In TANGO:H players get stars as rewards. A player can get the maximum amount of stars if you reach the highest score possible.

Table 2b Gaming elements

Elements	Description
Levels	The levels are related to the user experience or level of expertise (expert users, beginners, etc..). They are to shorthand indicator of status in a community and show that you should be afforded respect for your accomplishments. In order to make rehabilitation exercises adaptable to the different users, we can define in TANGO:H different difficulty levels in the game depending on the characteristics, skills and the evolution of each user. TANGO:H has several configurations parameters to customize and adapt the exercises to different users, such as: timing, action range, and target resizing. **Timing** TANGO:H Designer includes the functionality to assign a time to the objectives of an exercise, in order to the user must have action on these objective for the stated time. This timing will be the same for all targets that make the exercise. The time parameter defined from the TANGO:H Designer is included in the XML definition of exercise. Furthermore, it can also particularize timing with a factor that is assigned to the user. The factor is defined from the user form in TANGO:H and stored in the user information database. All these settings for timing, both the exercise and in the user's profile, is evident to the user through a clock that appears when the touch an object. The clock is filled continuously until completion defined time while executing the exercise. This is when the goal reached is given as valid. **Action range** TANGO:H Designer includes the functionality to assign an action range to the objectives of an exercise. This action range shall be equal for all targets that make up the exercise, and requires the timing described in the previous section to detect whether or not the user is willing to play or is a step movement. The action range parameter defined from the TANGO:H Designer is included in the XML definition of exercise. It may also particularize this range with a factor that is assigned to the user. All these settings for action range, both in the performance and in the user's profile, are evident in TANGO:H to the user executing the exercise, because when the user touches within the range (not necessarily in order) start counting the timing clock. This functionality can also create difficulty levels for exercises and users, and enables the designer to create groups of exercises that require different skills from simple to more complex. The level can be adjusted depending on the user's progress in treatment within the possibilities and needs of each patient [7]. **Target resizing** TANGO:H Designer includes the functionality to resize an object to the size you want. This behaviour is achieved by inheriting behaviour transparent goal from the beginning was configured as resizable. This option allows the designer to create goals that are easier to reach also more difficult targets, allowing adaptation to users who have more difficulties in their movement, creating difficulty levels. This also allows professionals to work on the user's motivation, ensuring that all users will be able to achieve the objectives as appropriate. So, the designer can go adjusting the level of difficulty as the possibilities of each user.
Avatar's Customization	TANGO:H has different avatars with which the user can be identified. The goal the customization of avatar is to increase the sense of immersion and the feeling of affection for the character with which the user identifies.
User satisfaction	This feature was implemented to obtain the end-user feedback after the completion of each game on the platform TANGO:H. To determine the user' satisfaction after the execution of an exercise, at the final phase of the game a set of emoticons specially designed for the platform TANGO:H is shown. Emoticons represent different emotional categories (positive, neutral and negative). Depending on the age entered for the user, the numbers of smiles shown vary, because the older has more emotional discrimination power.

4.0 IMPLEMENTATION AND VALIDATION

The Operating System (O.S.) employed as development platform has been Microsoft Windows 7©. When choosing the development platform, a study involving different alternatives was undertaken (drivers are available for all O.S. such as Linux). One of the main factors considered when choosing Microsoft Windows © was its compatibility with Microsoft Kinect ©. Another important factor in the decision is the large user base that this Operating System has, taking into account the objective to distribute the application to the largest number of users as possible. The developed software has been implemented in C# on the .NET platform. The use of this platform guarantees the correct

functioning of the application on Microsoft Windows © and eases the portability to future versions of this Operating System. In order to interact with Microsoft Kinect© the drivers developed by PrimeSense™ and the OpenNI™ libraries. OpenNI™ is an Open Source Framework that allows to develop applications for the Microsoft Kinect© device.

OpenNI™ allows abstracting the data obtained from the device and using them to interpret the user position and pose through the generation of a virtual skeleton. This representation consists in thirteen contact points represented by different limbs and joints of which their position and orientation can be obtained in real time.

The system development has focused in maintaining as much flexibility in exercise creation without affecting the usability of both product components. Additionally, the application has to adapt itself to the needs of the user. Therefore, it was crucial that the application was highly configurable and able to cover the cognitive needs or physical rehabilitation requirements. So, the adaptation is achieved through the logic introduced in application background responsible of executing the exercises defined in the XML.

We have followed in the design a User Centred Design (UCD) methodology [8], and validate the TANGO-H playability, usability and functionality with experts and children [9]. Note that 13 educational playability heuristics were evaluated, obtaining as educational playability average a value of 2.9, among values from 1 to 5.

Figure 3 Validation of TANGO:H conducted with experts and children

6.0 CONCLUSIONS

In this paper is described the design and development of a KINECT-based interactive platform, called TANGO:H. This platform is adaptable to the characteristics of the population it is intended: children hospitalized and in home care. Also, it is highly configurable and customizable, thanks to exercises editor: TANGO:H Designer. This feature allows health professionals and educators to create game-like exercises, adapted to the specific needs of end users and to the context in which the intervention will take place.

Moreover, due to the diversity of users it targets, TANGO-H is an accessible platform that allows interaction with information systems without physical contact with the traditional control systems using KINECT sensor.

Therefore, this tool allows compensation for physical inactivity of children in situations of illness and aims to help young hospitalized people in their recovery and, at the same time, support health professionals and educators. Also, this tool will help to normalize children providing them quality of life and wellbeing.

Also, most relevant gamification techniques are presented. The challenge of our work was include these techniques into the specific design of TANGO H. Moreover, we have added engagement and personalization techniques, such as “action range”, “target sizing”, “avatar customization” among others.

Furthermore, an user satisfaction test were added at the end of activity, to know the child emotions at the end of each exercise in a non-invasive way.

In addition, TANGO H platform has been effectively used by children during an intervention done in a primary school context. This intervention took place during four months, with very positive feedback from the children. The platform is also being currently used in hospital classrooms of the islands of Tenerife and Lanzarote, Canary Islands (Spain).

Acknowledgements

This work is funded by the research Project VIDEM: "Developing healthy habits and physical education through Educational Games for Hospitalized Children”, Ref. EDU2010-20010 of Spanish Ministry of Science and Innovation, and Project SALUD-in: “Interactive Virtual Rehabilitation Platform based on Social Games for Health” Ref. PI2010/218 from ACIISI.

References

[1] Gonzalez C., Toledo P., Alayon S., Munoz V., Meneses D. 2011. Using Information and Communication Technologies in Hospital Classrooms: SAVEH Project. Knowledge Management & E-Learning: *An International Journal (KM&EL).* 3: 1.

[2] Alankus, G., Lazar A., May M., and Kelleher C. 2010. Towards Customizable Games for Stroke Rehabilitation. In Proceedings of the 28th International Conference on Human Factors in Computing Systems. ACM. 2113–2122.

[3] Cameirao M., Bermudez I., Duarte O., and Verschure P. 2009. The Rehabilitation Gaming System: A Review. *Studies in Health Technology and Informatics.* 145: 65.

[4] Zichermann, G. and Cunningham, C. 2011. Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps. Sebastopol, California: O'Reilly Media.

[5] Prensky, M. 2005. Engage Me or Enrage Me. What Today’s Learners Demand. In Educause Review, September-October 2005. 40(5): 60–65.

[6] González-González C.S., Blanco-Izquierdo F. 2012. Designing Social Videogames for Educational Uses. Computers & Education. Elsevier. 58: 250–262.

[7] Hutzler, Y. and Sherril, C. 2007. Defining Adapted Physical Activity: International Perspectives. *Adapted Physical Activity Quarterly*. 24(1): 1–20.
[8] Nicholson S. 2012. A User-Centered Theoretical Framework for Meaningful Gamification. Proceedings GLS 8.0.
[9] González, C. 2012. Student Usability in Educational Software and Games: Improving Experiences. Advances in Game-Based Learning (AGBL) Book Series. IGI Global.