Can Game-Based Therapies be trusted? Is Game-Based Education effective? A systematic review of the Serious Games for Health and Education

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Abstract— **This review sets out the lines of development and research currently being conducted into Serious Games which pursue some form of benefit in the field of personal health. Although video games are traditionally associated with software developments, developing them in the social and health-care field involves studying the associated hardware and paying attention to aspects related to interaction with the game. Serious Games for Health cover matters related to education and the treatment of illnesses, awareness enhancement and psychological treatment, as well as training doctors in surgical techniques, for example. This chapter includes a review of relevant Serious Game developments over the last ten years and examines new trends.**

Keywords- Serious Games, Healthcare, Applications

I. BACKGROUND

A video game is first and foremost a form of entertainment, a challenge to achieve a goal, but a "Serious Game" goes further than simply providing entertainment. These types of game are normally associated with education and learning new concepts and skills, but they are also used for commercial purposes, for awareness enhancement and for denouncing social or political situations.

There are various classifications of Serious Games, but the most widely accepted? popular? one includes the following categories: advergaming [1] (advergames consist of interactive video games that allow the user to be continually exposed to the brand or product being advertised); educational games [2], health games, political, religious and social games.

The concept of Exergaming involves new ways of playing and new video game competitions that recreate sports, leisure time exercise and healthy exercise.

This review focuses on Serious Games oriented towards the medical and social sector. These are neither the most plentiful nor the first serious games to be launched, but they are gaining major recognition and relevance because of the results obtained with them in the sector.

Moreover, changes in technology and the large number of formats available make video games a tool that can be oriented towards the treatment and education of different sectors of the population, including:

- Children
- The Disabled
- The Elderly

The latest technologies mean that synthetic characters and emergent narrative can be developed to create improvised educational scenarios:

- 3D animated videogames
- Virtual reality
- Augmented reality
- Mixed reality

The serious games application is intended to help professionals, as well as enabling users to enjoy themselves through straightforward, real interaction while learning how to cope in several real social situations.

Developers of serious games for health must meet:

- Medical Objectives: to treat and inform about diagnosis or to rehabilitate people from different groups with or without functional diversity, with the aid of a user-friendly, simple and attractive tool.
- Technological Objectives: to design and develop accessible computer applications that implement games with semi-real characters.
- Social Objectives: to aid education, integration and socialization at home, at school and in urban environments.

The main aim of this chapter is to provide an overview of the potential market for serious games development in the field of education, diagnosis and treatment of health problems.

The specific objectives are described below:

- To describe the technologies that are most appropriate for developments in the field of improving health and social problems.
- To assess (multi-)platform possibilities: PC, cell phone, consoles and emerging devices, such as Microsoft Surface.

- To review national / international case studies and developments.
- To increase knowledge on ICT Applications among medical professionals/ psychologists.

This paper is divided into the following main sections: Section 2 describes the methodology followed by the authors to study the serious games state of the art, Section 3 presents the reviewed serious games, Section 4 explains the kinds of evaluation, and Section 5 and 6 concludes and introduces the author's thoughts.

II.METHODOLOGY

In this section, the criteria followed by the authors to choose relevant serious games, the main technologies used in their development and the possibilities around the interaction and multiplatform are described.

- Serious games Selection Criteria

A systematic review was conducted to identify some published articles describing representative advances in Serious Games area.

Only articles in English from 2003 to 2011 have been considered and projects from 7th Framework Program also.

Due the wide range of developed serious games, the search has centered in serious games for health and education.

- Technologies

Main technologies used in serious games development are: augmented reality and virtual reality.

Augmented Reality

Augmented reality is currently being used in such areas as architecture, where it is employed to show the final result of a project still in its planning phase or the virtual reconstruction of a building in ruins. In the educational field it has been used more frequently for applications in museums or theme parks; leading companies have also used it as a marketing tool.

One of augmented reality's chief attractions is that any virtual figure modelled in 3D can be incorporated into one or more real patterns. In addition, any move or turn of this pattern is the equivalent of moving or turning the virtual figure.

Thanks to augmented reality, Serious Games scenarios combine the real environment scenario with virtual objects, displaying a single mixed environment to the user, thus making him feel more involved and identified.

Virtual Reality

Virtual reality technology is used for the development of serious games. Using this technology, a wide variety of areas, such as medicine or education, has been developed from serious games. Thanks to the use of this technology [3] it has been possible to reconstruct different situations or environments that would be impossible to recreate in the real world, such as a traumatic situation, and thus help in the rehabilitation of individuals.

Through virtual reality, you can manage to get the user fully involved; this is achieved by using different hardware that lets you interact with the serious games having this technology implemented. The following are the major types of hardware currently available:

- 3D vision goggles
- 3D LCD Screens
- Data Acquisition Glove
- The mouse or keyboard
- Sensor body.

- Interaction

There is currently a trend towards creating computerized versions of famous traditional games which can also be played online. The aim is to enrich the user's experience and to make the games an appealing alternative, capable of competing with present-day video games.

Depending on the activities and skills to be worked on with each of the games and the target group, interaction may be one of the aspects that needs to be developed with greatest care. The most appropriate tools are not always the traditional keyboard and mouse. Technology has moved on and there are a host of possibilities opening up in this area.

Interfaces are beginning to be tested that can read EEG (the brain's electrical signals) [4] and turn thoughts into movements in a virtual environment or in video games such as Pong. In the future these are likely to be useful for individuals with much reduced mobility.

- Multiplatform Possibilities

The latest advances in hardware and software mean that the presentation of videogames has changed. Video consoles and the videogames that have been developed for them now make it possible to go far beyond the field of pure leisure.

- Mobile devices: these have entered into many aspects of our lives. Their multiple possibilities make them very suitable for education in health and good habits.
- Consoles. Various companies, such as Nintendo and Microsoft, have developed adapted versions and video games of their Wii and Xbox consoles to address aspects such as physical exercise and training in social skills.
- Microsoft Surface

III. SERIOUS GAMES REVIEW

Apart from being a recreational activity, playing Serious Games also stimulates the development of basic learning skills [5], such as paying attention, visual-motor coordination, logical

spatial reasoning, visual perception, spatial structuring, spatial orientation and creativity, among others.

To date, virtual games have been aimed at entertaining. This trend has been evolving and changing and, in 2002, a group of learning specialists and video game industries were combined/joined forces to face a new challenge in the field of education. As a result, the "Serious Games Foundation" was created, which promotes serious games as a solution for education and health environments.

Since then, serious games have played an important role in people's lives. As the number of these games increases, so do the benefits they bring.

As shown in Fig. 1, thanks to the increased demand of these games, competition between companies is increasing. Therefore, they are forced to research continuously and, as a result, the technology which is used for these games develops at a faster pace.

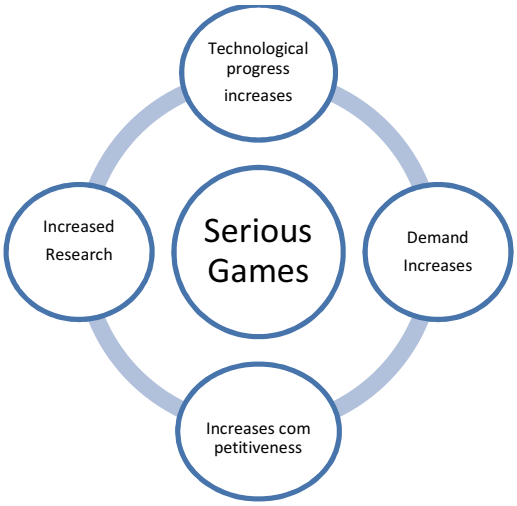

Fig. 1. Serious Games Demand Circle

The use of entertainment as an adjunct to medical care is not a new idea. Serious games in the healthcare area can be classified as follows, depending on what health disorders are being addressed: obesity, speech problems, rehabilitation, neurological disabilities, psychomotor coordination, etc.:

- Serious games for rehabilitation
- Serious Games for educating/training professionals
- Serious Games for education/knowledge of a disease/pathology
- Others: bullying, intercultural empathy, social interaction improvement…

Since the 1990s there has been increasing interest in developing Serious Games for Health. This interest has extended to an international level and investments are being made to increase variety among games for health.

The background of this subject has been divided into three groups in order to classify them according to their purpose.

- Serious Games for Rehabilitation. Their main aim is to help people during the rehabilitation process, making the exercises easier and more fun than with the traditional method.
- Serious Games for educating/training professionals. These serious games are designed to help professionals during the learning process.
- Serious Games for health prevention and education. Depending on the people to whom the games are oriented, they work on aspects such as: diet, sports, hygiene, social abilities…

The following list describes some relevant videogames from the last decade according to the classification described above.

A. Serious Games for Rehabilitation

The following developments are some of the most representative Serious Games for Rehabilitation:

- CAREN [6-7]. Computer Assisted Rehabilitation Environment is a multi-sensory system for diagnosis, rehabilitation, evaluation and recording. The system works in real time and enables the creation of a range of experiences in a controlled environment that can be repeated using the principles of virtual reality technologies.
- Virtual Environments for rehabilitation [8-10]. This field is one of the most intensely developed. Nowadays, using new technological possibilities is easy and feasible, and new consoles, such as Nintendo Wii and Xbox Kinect, offer many functionalities.

Both serious games make the most of benefits of the technologies to create appropriate environments. Thanks of them the rehabilitation is more quickly and effective.

B. Serious Games for educating/training professionals

The main goal of the applications described below is to educate or train health professionals:

- Pulse!! Virtual Clinical Learning Lab for Health Care Training [11]. “Pulse!! Immersive virtual learning space for training health care professionals in clinical skills”. Cutting-edge graphics recreate a lifelike, interactive, virtual environment in which civilian and military heath care professionals practise clinical skills in order to better respond to injuries sustained during catastrophic incidents, such as combat or bioterrorism. Pulse!! is being developed in partnership with Texas A & M University - Corpus Christi and is funded by a federal grant from the Naval Research Department of the Navy's Office (see figure 2).

Fig. 2. Pulse Game Screenshot

- Virtual Dental Implant Training Simulation Program This groundbreaking project (see Fig.3 and 4), developed by the Medical College of Georgia and, funded through a grant from Nobel Biocare, was created to offer dental school students and dental professionals better teaching and training in patient assessment and diagnosis protocol and to allow them to practise dental implant procedures in a realistic, virtual, 3D environment.

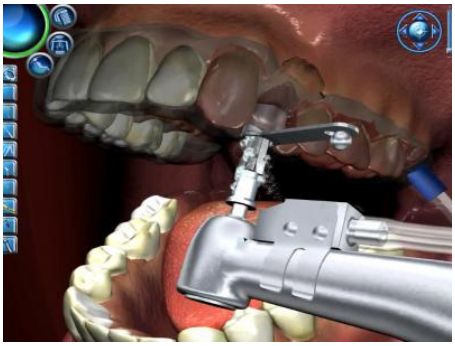

Fig. 3.Virtual Dental Implant Training Simulation Program Screenshot Zoom

Fig. 4. Virtual Dental Implant Training Simulation Program Screenshot

- RescueSim [12]. Virtual Emergency Response Training is software that prepares safety and security professionals for real-life incidents and which allows them to experience and train themselves for incidents in a safe virtual 3D environment.

- NAUTIS [13]**.** Maritime Simulation Training. A new generation of affordable advanced maritime training solutions and simulators for the military & civilian maritime industry.

- HumanSim (see Fig.5) [14] has been developed by Virtual Heroes. This serious game is a software simulation Platform that provides enhanced initial, refresher and sustainment medical education and training. Virtual Heroes has developed this serious game for the Ipad.

All of them have a great quality graphics. With the previous described games and due to their graphics quality, it is achieved the users are more involved and to give more realism to the different situations. This kind of games is a good tool to the educating and training professionals.

Fig. 5.HumanSim Screenshot

C. Serious Games for health prevention and education

The main goal of the applications described below is to work in healthcare prevention and education:

- EyeOk [15] The project was developed in 2009 by AIDO with collaboration from the Official Association of Opticians and Optometrists from the Region of Valencia (EASD), the Higher School of Art and Design in Valencia and the Valencia Sight Institute (IVV), with help from the Ministry of Industry, Tourism and Trade through the Avanza Plan.
  EyeOk (see Fig 6) is a virtual info-educational gaming environment intended to improve visual health, enable detection and facilitate prevention of sight problems, as well as publicising good practice in this area. It has various goals:
  - To provide broad sections of the population with access to digital content for improving visual health based on on-line, interactive and multimedia games.
  - To allow significant learning in visual health good practice and ergonomics through educational video games.
  - To provide a digital tool that can identify and prevent visual dysfunctions. To support, through the interactive game, good use of visual aids (spectacles, contact lenses, special lenses for poor sight, etc.).
  - To support early identification of sight problems using games and virtual simulators for running optic tests based on digital developments accessible on-line.

Fig. 6.Eye Ok Screenshot

- Food About [16] (see Fig 7) is developed by the IAB Foundation (run by the Food and Drink Industry) with the collaboration of health professionals. The purpose is to positively influence the eating habits and lifestyles of teenagers in a gaming environment, promoting healthy lifestyles based on a balanced diet and regular physical exercise.
  The game involves keeping up suitable levels of energy, health, habits, physical form and cohesion associated with the character chosen throughout the game.

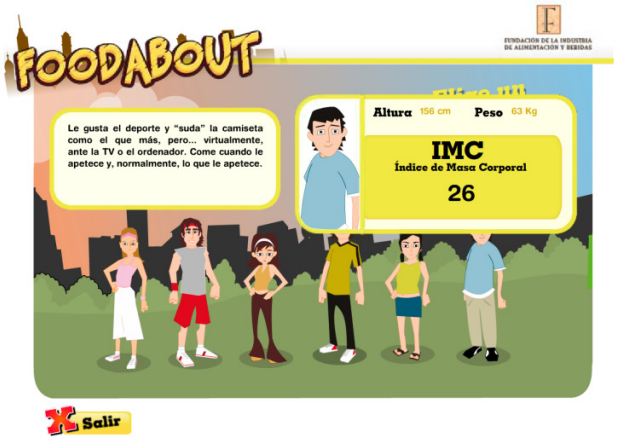

Fig. 7.FoofAbout Screenshot

- FatWorld [17] has been developed by Electric Shadow and created by Ian Bogost. The idea is to instill the habit of eating well among children. Children must create a character to their liking and then ensure them their food, taking care of the consequences of an unbalanced diet or malnutrition. Your character can be sick or even die if not fed regularly, doesn't play sports, doesn't keep fit, etc.

- The Food Detectives Fight BAC! [18] The game (see Fig.8) tries to teach children how they should deal with food before cooking it, how to keep things clean, thus preventing diseases related to poor treatment of food.

Fig. 8The Food Detectives Fight BAC!

- The Eco-Consumo [19] project aims to instill new knowledge complementary to the subject of Knowledge of the Natural, Social and Cultural Development of Graduate Students in Primary Education. Immersed in a 3D environment, learning takes place by "playing" responsible drinking habits.
- Neuro- psychological treatment [20]. The main aim is to analyze the behaviour and to promote certain social skills (conversation, negotiation…) of people with neurological development disabilities (see Fig. 9).

Fig. 9. Social Skills treatment serious game screenshot

- SIREN: social games for conflict resolution based on natural interaction [21]. The siren project aims to create a new type of educational game, the conflict resolution game, which takes advantage of recent advances in serious games, social networks, computational intelligence and emotional modelling to create uniquely motivating and educating games that can help shape how children think about and handle conflict.

- MunchCrunch: A game to learn healthy eating [22]. The goal of this Flash game is to help adolescents learn simple and useful heuristics about healthy eating.

As it observes, there exists a large variety of serious games oriented to health and education. All of them explain and give information about the topic that they want to deal. Besides, they show a suitable graphics for the objective public.

D. Others

The following projects related to serious games and healthcare not included above can also be found.

- Hospital-based Online Paediatric Environment (HOPE) [23]. This is a network that will provide paediatric patients with an opportunity to meet, socialise, and (most importantly) play games with other patients in hospitals around the country.
- Fear Not [24]: Developed in 2005 by Heriot-Watt University in Edinburgh, this is a 3D virtual application intended to teach children how to respond to harassing behavior, i.e. a tool was developed to deal with ethically sensitive issues.
- ECOBUDDIES [25]: EcoBuddies Interactive Ltd. is a Vancouver-based company and it has developed a virtual world that revolves around the environment. It aims to introduce children aged 5-12 years to eco-themed activities and games.
- WHYVILLE. This virtual world is thought to pre-teens education, as in the previous case, but also goes to higher levels. According to its creators, its design seeks to promote learning through playing and interaction. Many of the activities and experiences are based on art and science. For this reason, Whyville has an extensive and growing sponsorship, ranging from the NASA Centers for Disease Control and Prevention of Disease to Yemi Disney, among others.
- POR(Disseminate the power of research through an on-line simulation of the scientific endeavor) [26]: A project dedicated to bringing and disseminating the scientific world among the young.
- Therapeutic tool for elderly people [27]. This project presents the development of a therapeutic tool based on the game of Tangram using augmented reality techniques. The therapy continues to employ the traditional physical pieces, but the patient is able to enjoy a much more entertaining experience when doing the exercises. At the same time, the augmented reality means that obtaining important information can be automated so that the therapist may recreate and assess the patient's exercises (see Fig. 10).

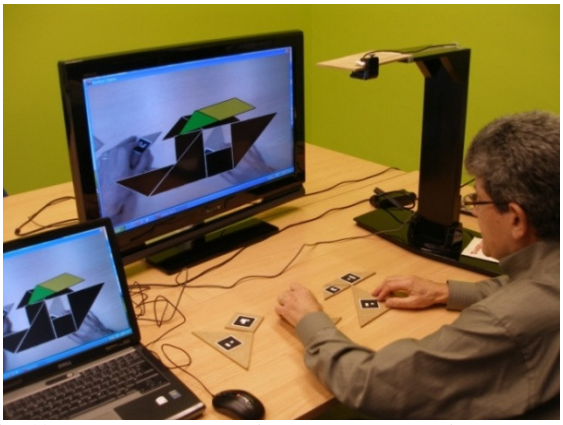

Fig. 10. Elderly people playing augmented reality Tangram

IV. EVALUATION

To make complete serious games evaluation and to check that they achieve the goals, it is necessary to make different tests to the users to assess the results.

Users:

The users are the main character to evaluate the serious games. Because of that, it is important to establish the characteristics of the users who will aim the game.

If we are speaking about a game-based therapy, we have to choose the control group also. The users will be divided by gender, age, pathologies… to compare the results.

Evaluation Methods:

After the test with the users, it is convenient to take into account their subjective impressions.

The evaluation process is very hard due to the difficulty of objectifying the efficiency markers. Sometimes, the information is obtained though:

- Satisfaction surveys (see an example in Table 1).
- Personal Interview. The interview consists of several open questions in which the user can discuss different aspects of what he felt or improved, thanks to the game.

Table 1. Satisfaction Survey Example

Question	Score
1. Is the application intuitive to use?	
2. Is the application easy to interact with?	
3. Is using the Wiimote an attractive feature?	
4. Can you relate to the different scenarios developed in the application?	
5. Is the explanatory information provided for each option chosen useful?	
6. Is the reward system for completed levels a good technique for motivation?	
7. Overall evaluation of application	

V. CONCLUSIONS

After researching many serious games, both conference presentations and lectures, the authors see that they are being incorporated gradually into education and health. It leads to the conclusion that they can be a good support compared with traditional methods and it provides the advantages of the use of technologies, such as to create appropriate environments and get users to engage in a more rapid therapy.

After the experiment and the evaluation of different projects, the following benefits can be underlined in reviewed serious games:

- Social Benefits

The therapy concept is changed to a game concept in order to improve the users' motivation.

- Medical Benefits

The applications collect some parameters associated with the therapy. They allow an objective assessment of the learning/therapy process. An example could be the measurement of the time needed to access the following level in the video game.

Fig. 11. Always connected architecture for Serious Games

Specialists have recently been demanding that Serious Games of this kind be included in their daily practice because they provide a more recreational vision of activities assessing and measuring the progress of certain therapies.

Finally, the serious games can be a reliable and effective tool when they are used as a method of education, due to thanks to them, the users are more encouraged and they memorize the concepts that the serious games want to teach better.

VI. Discussion

There are some experts in games area such as Tom Chatfield [28] and Jane McGonigal who say that thanks to games it is possible to stimulate the brain and can improve the world [29]. But, serious games are really (or could be) so important in our lives? The serious games can show us the consequences of our actions (i.e. related with our health in the future). Is it necessary the use of virtual worlds to work different skills? Can we reproduce all the situations in a virtual way? Are they valid in all aspects of life?

In the literature, studies show that games are very effective in the areas of health and education [1-28].

Acknowledgments

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