

# Serious Games in Autism Spectrum Disorder

## *An Example of Personalised Design*

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**Abstract:** Over the last decade, several studies evaluated the use of Serious Games as tools to encourage the development of communication, the process of learning, and social behaviour in people with Autism Spectrum Disorder (ASD) alongside traditional therapeutic approaches. The proposed study intends to employ and rate the use of Serious Games to create personalised interactive environments aimed to improve the learning of educational content in children with ASD. In particular, a multidisciplinary team supported the design and development of the serious game to allow a personalised approach.

## 1 INTRODUCTION

A Serious Game (SG) is a simulation with a videogame structure whose purpose is to promote the development of important skills and strategies in order to increase the cognitive and intellectual abilities of the users (Botte, Matera, Sponsiello, 2009).

Today, Serious Games, also called learning games, educational games, immersive learning simulations and game-based learning, are very popular and they get significant market share in the gaming industry (Alvarez et al., 2010).

Several studies evaluated the Serious Games use as a tool to support traditional therapy for people with Autism Spectrum Disorder (ASD) in order to improve communication, learning, social behaviour and, in different ways, motor abilities (Zakari, Ma, Simmons, 2014).

The purpose of our research is to investigate Serious Games use in the Autism Spectrum Disorder field. In particular, a first Serious Game prototype was developed to improve the learning of mathematical basics in children with ASD, promoting a personalised design.

### 1.1 Serious Games and Autism Spectrum Disorder

Autism Spectrum Disorders are a variety of disorders that affect social and communication skills and, in a different way, motor and language skills (American Psychiatric Association, 2013).

The majority of Serious Games aimed at people with ASD have been developed for therapy, education (learning and training), and to improve social communication skills (Noor, Shabodin, Pee, 2012).

Serious Games, which are developed to improve the learning process, have the goal of helping children or teachers during the learning process. Bernardini et al. (2014) have developed ECHOES, a SG that improves learning and communication in children with ASD using an avatar. Laertius et al. (2015) have implemented a digital game, TEO (Tratar, Estimular and Orientar), to help children with ASD with learning, communication and problem solving. Developed by Van Veen et al. (2009), Racketeer is a learning Serious Game for Autistic children with the purpose of improving their mathematical skills and helping them cooperating with others.

Wijnhoven et al. (2015) have been studying the efficacy of Serious Game MindLight in decreasing anxiety in children with ASD.

People with ASD often have difficulties in communicating with others through both verbal and non-verbal language. For these reasons, several

Serious Games have been developed to reduce these difficulties (Anwar et al., 2010).

People with ASD often have difficulties in recognizing, understanding and expressing their emotions, therefore several studies investigated the development and the improvement of affective skills in children with ASD through Serious Games (Alves et al., 2013; Serret et al., 2014; Parsons, Mitchell 2002).

Bernardes et al. (2015) have published a study about a SG for training people with ASD to use the bus. De Urturi et al. (2012) have implemented a Serious Game for Android that educates people with ASD about first aid. Another important Serious Game developed in the field of training is iSpectrum; it was developed to improve the working abilities and skills (Amoroso, 2012).

A few studies also evaluated the impact of commercial videogames on people with ASD. FaceSay (Hopkins et al., 2011) and Segret Agent Society (Beaumont, Sofronoff, 2008), for example, can help children with ASD to develop social abilities and understand emotions.

## 1.2 A Personalised Approach

Personalization can be associated to different aspects of a videogame (Bakkes, Tan, Pisan, 2012) and, consequently, of a Serious Game. Kalloo et al. (2010) investigated the use of personalized games in supporting students' learning of mathematical skills. Moreover, another use of personalization in Serious Games is content adaption to improve the learning process (Brisson et al. 2012, Zarraonandía, Diaz, Aedo, 2015).

A personalised approach is also of pivotal importance in developing Serious Games for people with ASD because when we talk about the Autism Spectrum Disorder we are referring to a large set of different features, which can evolve over time. In fact, one of the most famous quotations about autism is: "If you've met one person with autism, you've met one person with autism" (Stephen Shore).

For these reasons, it is necessary to carry out a suitable customized intervention (Franzoni, Hanau, Cerati, 2008; Wehman et al., 2016) based on evolution and changes. Moreover, it is important to consider the personalization of both accessibility of technologies (Hassan et al., 2011; Uzuegbunam, Wong, Cheung, 2015) and content (Morris, Kirschbaum, Picard, 2010) in the development of a SG aimed at people with ASD.

In our study, we adopted a personalised approach in the content learning aspect and game design.

The first step was to create a multidisciplinary team; in fact, Serious Game development has to involve videogame specialists like game designers, programmers or graphic designers, as well as other professional figures unconnected to technical development (Diehl et al., 2013). In particular, we formed a team of biomedical engineers, one neuropsychiatrist, speech therapists, educators, and parents of children with ASD.

The project team, knowing the specific needs of the target group, established the elements of personalization, the content to be learnt, content learning, the design and development of our SG.

## 2 METHODS

We implemented an ADDIE methodology (Kirkley, Tomblin, Kirkley, 2005) to devise our Serious Game. In particular, we can summarize the different steps in six phases:

- analysis,
- design,
- development of a prototype,
- testing,
- implementation,
- final testing- evaluation.

### 2.1 Analysis

Different elements, such as target groups and project development, are evaluated during the analysis phase. In particular, several general considerations were drawn:

- creating an interesting game environment;
- gaming scenes where water is involved (beach, swimming pool) are to be preferred;
- creating a system feedback (audio, music);
- helping the player to perform the action.

On the basis of these observations, the project team established the target groups: 10 children aged between 5 and 12 years with different cognitive skills. For each child, personal and health data were collected, as well as information about their usage of technological tools.

### 2.2 Design

The design determinates how desired outcomes are to be achieved. The team draws up a design document (Whyte, Smyth, Scherf, 2015) that describes the game and establishes content, purpose, storyboard, scenery, player, user interface, and

feedback.

### 2.2.1 Purpose

Based on the cognitive skills of the target group, the project team decided that the game's purpose was to improve mathematical skills, namely the concepts of number and quantity: our SG aimed to be a tool of help and support to children with ASD learning basic mathematics.

The Serious Game consists of eleven levels in which the player has to collect the balls on the scene; the number of balls increases with each level. The first level introduces the game, directing the player, while the final level allows for free exploration of the scene.

### 2.2.2 Scenery

In order to create a personalised SG, the project team decided to implement an environment that was familiar to the children's target group as a game scenery. Specifically, the scenery is a swimming pool with the same features of a real swimming pool where the children used to undertake different activities. A personalization of scenery allows the users to identify with the game, so that they are more interested to play.

### 2.2.3 Feedback

The feedback system is delivered through audio, writing and images. In particular, when the player collects a ball they receive a positive feedback through a sound. Moreover, at the end of each level it was established that an object was to appear on the scene with particular graphic effects: a three-dimensional number of total balls collected.

### 2.2.4 User Interface and Player

The user interface has to be easy and intuitive, showing the videogame's mission and the number of balls collected. In particular, the game's mission is displayed through text and images.

The player is put in a first-person perspective that the user can move with a keyboard and a mouse.

Table 1: Player Controls.

To go on	↑ keyboard
To go back	↓ keyboard
To go right	→ keyboard
To go left	← keyboard
To jump	keyboard space
To move camera	Mouse

### 2.2.5 Platforms

The project team evaluated the systems requirements best suited for implementation. Unity was chosen for the game engine both because it had already been used in the development of small/medium videogames and because it allows the game to be exported to different platforms, such as Windows, Android, Nintendo or Xbox. 3D Studio Max was employed as a 3D modelling software.

## 2.3 Prototype Development

The prototype development phase consists in the implementation of a first game prototype and in the development of the design plans.

The first step was to create 3D models of the scene's different objects, such as beach umbrella, deck chair and the arch. For these reasons, photos of the swimming pool were collected so that we could visualize the scene objects. The majority of the objects were modelled through a 3D modelling software, while the rest were downloaded from the Unity Asset Store.

After the 3D modelling, the game environment was created and the game dynamics was implemented through scripts in C#.

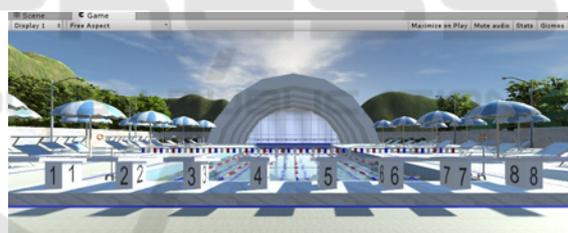


Figure 1: Game Scenery.

The prototype evolved into a PC and web application with six different levels.

## 2.4 Testing

Testing is an important, if sometimes neglected, phase of SG development (Olsen, Procci, Bowers, 2011). In this phase, user usability (especially in prototype development), playability and the efficacy in the learning process have to be evaluated (Desurvire, Caplan, Toth, 2004).

The project team decided to realize two testing phases. The first testing phase evaluated the SG prototype to obtain an initial feedback and to consider, if necessary, a possible redesign of game elements to implement on the complete SG.

The final testing is carried out on the SG and it has to evaluate and measure its effectiveness and efficiency.

The testing phases consist of two tests: a software and a user test. In particular, a test plan was created establishing some aspects of the testing session like the place, the figures involved and the modality of execution. A methodology proposed by Moreno-Ger et al. (2012) was adopted so that an event set to evaluate the system operation, the usability, the efficiency of personalised elements and the achievement of the SG's goals was considered. Moreover, each test is a set of game sessions and all sessions have to be recorded, easing the analysis of the results.

After the testing phase, it became necessary to analyse the collected data and to discuss the obtained results.

The prototype game, designed for PC, is currently undergoing testing with users. From the results of the first phase of testing, it will be possible to rate the elements that have to be redesigned for the development of the Serious Game, while a first estimate of the learning process and skills acquired will be made.

### 3 DISCUSSIONS

This study sets out to explore the possibilities of using Serious Games to improve and help the learning process in children with Autism Spectrum Disorder. Moreover, a multidisciplinary team is necessary to develop a Serious Game aimed at people with ASD because it is important to consider their different needs and requirements. The multidisciplinary team chose the target group and analysed the different aspects to develop during the design and the implementation of the game.

In particular, a personalised design is proposed in order to adapt the content to the player's specific needs and to motivate them to play.

Whether the personalised approach is valuable is not yet clear because the testing phase is at its initial stages, although preliminary results show success in the target group.

The prototype is proving to be attractive and enjoyable, with a good usability, but the testing phase is being reviewed because of certain limitations. It is not easy to organize the different testing sessions because of the children's availability. Moreover, not all participants are testing the prototype at the same time, but at different times of the day, meaning that for example a child playing after school or therapy

could be less motivated to play. For these reasons, the testing sessions have to take into account several other aspects, from the specific needs of the children to when the game was played.

After the testing phase, the SG development will be completed.

### 4 FUTURE WORK

On the basis of this preliminary study, we want to investigate the use and efficacy of personalised design in Serious Games aimed at people with ASD. Future work should consider the need to incorporate other personalised elements (like avatars or specific audio effects) and more than two players at the same time. Moreover, new methodologies for the testing and the evaluation of content learning will be investigated.

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