# A Serious Game about Recycling Rules

N. Jofré, G. Rodriguez, Y. Alvarado, J. Fernández, and R. Guerrero

Laboratorio de Computación Gráfica (LCG) - Universidad Nacional de San Luis,
Ejército de los Andes 950
Tel: 02664 420823, San Luis, Argentina
{npasinetti,gbrodriguez,ymalvarado,jmfer,rag}@unsl.edu.ar

**Abstract.** Nowadays serious games is one of the biggest existing industries and it is still growing steadily in many sectors. As a major subset of serious games, designing and developing virtual reality applications to support education or promote social behavior has become a promising frontier, because games technology is inexpensive, widely available, fun and entertaining for people of all ages, with several health conditions and different sensory, motor, and cognitive capabilities.

In this paper, we provide an overview about a serious game with a perspective of virtual reality for social behavior. The work uses a serious game in an immersive learning environment for recycling learning. In order to improve the user experience the game was developed to work in a cave-like immersive environment, with natural interaction selective alternative.

The game includes static and dynamic 3D environments, allowing to share the experience of scenario navigation among users, even geographically distributed.

**Keywords:** Serious Games, Virtual Reality (VR), CAVE, Computer Graphics.

## 1 Introduction

For some time now, virtual reality has allowed the generation of interaction environments that facilitate new contexts of exchange and communication of information. More specifically, the employment of Virtual Reality is a natural idea to improve the impression of living in a simulated reality, so this tool is largely used in many areas such as medicine, industries, education and entertainment [1].

In entertainment industry, in particular, the creation of computer games using different technologies, rules and goals among others, has grown considerably. Today, playing computer games has become a popular activity for people of different cultures and ages. This habit motivated game developers, educators and domain experts to create other kind of applications for computer game technologies [2, 3].

These new applications which aim to address a specific problem or to teach a certain skill are called *Serious Games* and mainly relates to interactive computer-based game software that intentionally produces games outside of entertainment, i.e games with serious purposes [3].

A serious game is designed based on different educational, training, informational and learning motivations. Specifically, game-based learning involving educational, cognitive and affective aspects induces learners/gamers to higher motivation and enhance their learning success. While there are inherent tensions between contemporary youth culture and traditional education, researches show that new learning game developments promise to help shortcutting the bridge of that growing generational divide. Besides as another positive effect of learning games is to allow the learning of knowledge and problem solving skills with better performance and long-lasting attributes [4]. At the moment, serious games have allowed to solve lot of problems from technological, medical, educational and environmental areas.

One of current problems in the world is the increasing recognition of the need to sustain an ecologically-balanced environment. A helping action to this problem is to reduce and avoid negative impacts of waste on the environment, being the diversion of biodegradable waste from landfills an important contribution to limiting greenhouse as emissions. In this context, serious games of learning using virtual reality are tools that add entertainment to teaching and training for adoption of sustainable development practices [5, 6].

Adopting these practices begins on bringing about behavior change. The designing process to enhance behaviors strongly dependent of intention, i.e the commitment to a certain action. Many times are deliberate acts based on the beliefs of the individual and the norms imposed by society [7]. When an individual is positively predisposed toward a particular behavior, and additionally perceives support for this from people around them, then it will form a positive behavioral intention towards that behavior [8]. Such collective behavior is needed on issues such as recycling, i.e a model of social behavior to enable this kind of "contagion" in social and sustainable problems such as waste recycling. In business world there is a new web-based model that harnesses the creative solutions of a distributed network of individuals through what amounts to an open call for proposals. This model is called *crowdsourcing* and its name is formed from two words, *crowd*, making reference to the people who participate in the initiatives, and the word *sourcing*, which refers to a number of procurement practices aimed at finding, evaluating, and engaging suppliers of goods and services. Literally, *crowdsourcing* means to outsource an activity to the crowd and for that it quickly began to be used in other areas such as entertainment, sociology, psychology and others [9, 10].

Particularly, this property of outsourcing it to an undefined (and generally large) network of people in the form of an open call allow to developers and researchers of serious games to use it in games that allow solve problems either collectively or competitively [11].

This work presents *Recycle Now!*, a serious-game-based virtual reality for enhancing recycling behaviors and environment awareness. Essentially, the idea is to develop a game for motivate and teach the basic principles of recycling and training about different types of recycling using the crowdsourcing concept to create a collective behavior.

## 2 The developed Serious Game concepts

Currently, even though in world there are many campaigns on recycling (*Wecycle*, *Plastic Hero*, among others) still exists a lack of awareness among people. Some people raise than this activity needs an extra effort since separating the garbage of their homes and putting it on their home's trash container it is a hard work, besides they don't want to dedicate more place to garbage in their homes. Certainly there are major problems like climate change, lack of protection of wildlife, landfills among others, which require the support of the whole society. Therefore people should adopt recycling good habits firstly at home and then apply them in public places [12, 13].

Finding a way to make from recycling a daily activity is not easy but as it was mentioned, serious games are an interesting tool to making recycling a fun and natural activity. Thus, a person could learn at his home the recycling's basic principles and then out into the world and unconsciously apply it. This behavior implies analyze several theoretical aspects which will be used for the development of this game.

### 2.1 Learning

Some time ago, new technologies have been incorporated to education as learning tools, particularly, people are finding ease increasingly in learning games environments. This game is presented as a game where the user can collect, identify and place trash. At the same time, other players may be doing the same task and also correct each other in order to earn more points. Apparently, the game can be categorized as competitive, but the learning is not; it is expected that at the end of every play each player ends up learning a little more about recycling practices [14].

Therefore, this game is based in a learning method called *Cooperative Learning*; which is an instructional approach in which learners work together in small groups to achieve shared learning goals. This approach invites group members to reach outcomes by setting and working towards a common goal, putting emphasis on cooperative evaluation of these outcomes. While learners are all on equal footing, great emphasis is placed on the responsibility of individuals [15]. Accordingly, the players of this serious game have one goal in common (recycle) and also each is responsible for the moves they perform. Finally, players are somehow cooperating with each other to adopt good practices for recycling.

### 2.2 Crowdsourcing

*Crowdsourcing* is evolving as a distributed problem-solving and business production model in recent years. In crowdsourcing paradigm, tasks are distributed to networked people to be completed such that cost and time can be greatly reduced.

Nowadays, many tasks that are trivial for humans continue to challenge even the most sophisticated computer programs, such as image annotation. These tasks cannot be computerized [16]. Current research in crowdsourcing often focuses on micro-tasking, however, participants are people with rich capabilities including learning and collaboration, suggesting the need for more nuanced approaches that place special emphasis on participants. There are no recent studies using learning among these approaches, so crowdsourcing efforts based on learning through a game is a good objective [17, 18].

As it was mentioned the *Cooperative Learning* model allows users to achieve shared learning using interaction between them. Specific situations where the user will be benefited from this concept are related to game dynamics. Some examples where the user learns by interacting crowdsourcing are: when it is a witness of another player's mistake, it corrects another player, or it is corrected by another player on its own mistakes. Clearly, all learning situations depend on the existence of the cross-interaction via network.

*Recycle Now!* is a serious game that combine crowdsourcing mechanism for learning purposes. In the following subsection we describe a framework that supports the learning mechanism with the mentioned crowdsourcing concept.

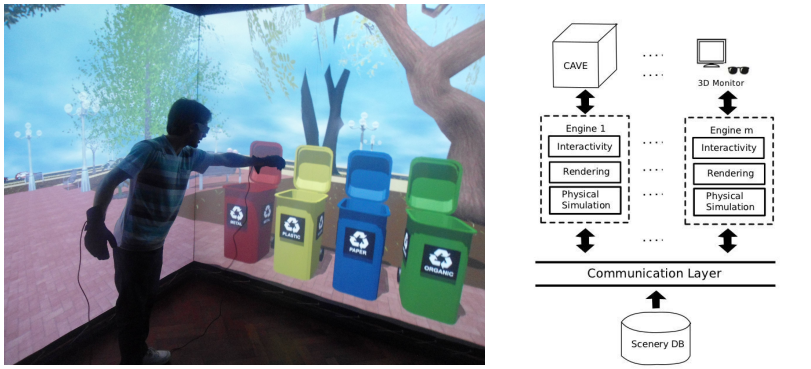
### 2.3 Platform

The game was developed to work on a computing platform for immersive collaborative 3D virtual world visualization (See Figure 1 (a)). It allows the use of geographically distributed VR media, called a multi-VRmedia. Remote players can interact into a 3D scenario through different multi-VRmedia. During navigation, players can exchange information in order to cooperatively solve the observed problems [19].

Each multi-VRmedia comprises the hardware and software necessary to gather the information obtained during interaction between user and game: via keyboard, mouse, data gloves, sound system, 3D active glasses, screen/projection surfaces, projectors, among others.

A computing platform includes a hardware architecture and a software framework (including application frameworks), where the combination allows software, particularly application software, to run. Typical platforms include a computer's architecture, operating system, programming languages and related user interface (run-time system libraries or graphical user interface). A system to visualize scenarios in a multi-virtual reality media environment has been defined. Such system will provide the necessary structure for attributes definition, rendering and collaborative multi-visualizations, as well as the needed interactive resources. Figure 1 (b) shows an overview of the work.

The system uses a client/server architecture similarly to a traditional network game, this allows user's interaction with others gamers distributed geographically.




(a) Immersive environment (b) Computing Platform

**Fig. 1.** Virtual Reality System.

## 3 GamePlay

According to Prensky, *"Gameplay is all the activities and strategies game designers employ to get and keep the player engaged and motivated to complete each level and an entire game"* [20]. This serious game offers a good gameplay combining a familiar and innovative **game design** and an educational and motivating **players experience**.

### 3.1 Game Design

Serious games must fulfill all the necessary and sufficient conditions to become a game. There are several aspects used in design of traditional games which pretends provide a good gaming experience to players. The most important aspects of the game are explained below.

**First-Person game.** Player perspective is one of the important design choices made when creating a digital game. Traditional camera options include audience, isometric, birds eye, trailing camera, third person and first person [21]. These views support distinctive experiences of immersion for video game play and different perception of the game space. First person (FP) allows the player to perceive the game through the eyes of the character, observing the world around them up close, giving a clear view of the scenario in front of them. As mentioned, this game is a game-based virtual reality and one of the pillars of VR is immersion. Therefore this game features a FP view to increase the feeling

of being immersed inside game, for example, when the player needs to put waste in the correct place using haptic devices, requires a vision close to the container. Thus this FP feature stablishes a "player-character" relationship to provide the most immersive feel for the player and improving learning abilities stimulating his visual and auditory capabilities.

**Multiplayer game.** In games world, most players want to share the same experience with other players, i.e seeing and feeling like they are playing the same game (being connected). A game meeting this feature is said to be a multiplayer game and *Recycle Now!* is not the exception [22]. The mainly reason making this multiplayer game is because the game's theme required the use of crowdsourcing' s concept, namely allowing another players to give a solution to an specific problem of the game. The mentioned game platform was built around a client-server architecture where each client connects to a single server resulting in the illusion of a shared experience but really each player is playing a separate game, each with its own game state. This feature allows meet an expected functionality for players and moreover a collective solution.

**Affordance.** Game engine has increasingly developed to include aspects like emotion, joy of use, user experience, or motivation. Therefore a concept has been sporadically applied to games for several years, this concept is known as "*affordance*" and refers to perception mapping what the external world affords the perceiver [23]. However games researchers try to explain how people discover the functionality of features in game applications. Particulary, virtual reality games developers have focused primarily on what players perceive they can do, as opposed to what players can actually do in an interactive virtual environment [24].

In this case in addition to offering a game with a serious purpose we wanted to give players a way to play to help their perception, granting them different means to traditional desktop game such as mouse and keyboard. It is for this reason that the game platform built allows some players to make use of tools such as 3D glasses, data gloves, body sensors among others, and so to increase its capacity and reduce perceptual cognitive effort. This way affordance is a powerful tool for understanding the relationship between player and system.

**Environment.** To achieve the proposed goals in the game, a scenario was developed as environment. The game was situated at the central square of a city, where the user can navigate for the square and streets around of it.

Stage was set with ambient sounds, inanimated objects (benches, lights, trees, garbage, trash cans) and animated objects (people) allowing social interaction, making the obtained learning through the game were similar to real world. Particularly, people on stage are avatars (See Figure 2).

**Physical realism.** Making an object looks real to the user more than visual realism is required. In a realistic game, objects also should behave as in reality

**Fig. 2.** Scenario.

including their physical characteristics, so it is necessary to simulate aspects like gravity and collision avoiding crossing between solid objects, achieving then a behavior like the impact of a ball on the ground and soft objects deformations, among others.

In addition user's movement basic physics, the game requires to perform collision detection for activities such as grasping and releasing waste. *Collision Shapes* are used for that like envelopes that allow sensing the world surrounding the object and making possible to visualize collisions between objects.

**Real time.** The virtual reality enables users to simultaneously experience real-time and interactive simulations. Real-time factors considered here are diverse: visualization, realistic audio, media interaction and user response times.

As was described in platform's section, real time is enhanced by haptics devices and others virtual reality devices. Because grasping and releasing waste is a key type interaction, a real-time hand gesture interface to manipulate objects in the game has been implemented. As an example, a user may see a simulated virtual representation of themselves (an Avatar) or a part of themselves (hands) that reflects real-time movements (e.g., lifting a finger, close the hand, etc.).

The developed game has the ability to interact with users in real time and receive feedback. The game allows users from around the world communicating, playing, learning and networking in real time.

### 3.2 Player's Experience

A good gaming experience involves keeping players motivated. To achieve this motivation both the game and opposing players must be a challenge for all players. Regarding players, an experienced player will not get the expected challenge

if it is playing with beginners. These possible differences in experiences must be balanced before starting to play. Consequently *Recycle Now!* provides different tools and documentation to help players who need it and reports on all relevant regulations about game.

**Rules.** Before starting the game, players must join to the same play, one player will be the server that created the play and others are guess. Initially each player has a set of different garbage containers labeled: *Organic*, *Plastic*, *Metal* and *Paper*, and they must decide where will place each of them on stage. To achieve a uniform distribution, players are prohibited placing containers near each other (See Figure 3). Once containers of all players are located, they can not be relocated.

**Fig. 3:** *Garbage Containers Distribution*

After it, game starts. Players must find the trash, collect, analyze and throw it in their containers. Players compete against each other for garbage pick up quickly and increase their scores. After a certain time, the game ends and the player with the highest score wins the game. All players can see the scores of other players while they are playing.

**Skills.** The game allows to see the score of players, showing who is the winning player so far. It also offers players the opportunity to discredit other players using an ability called "*Let me check!*". All players can execute this skill a certain number of times as they see fit.

When a disbelieving player (player A) wants to discredit a refuted player (player B), player A must execute "*Let me check!*" action. With this ability, player A can adjust player B garbage classification, and consequently player A score, increasing it for each right classification, and decrementing it for every wrong classification. The score of player B will be decremented only for each player A correct classification (See Figure 4).


**Fig. 4:** *Let me check*

After checking up Player B collected garbage, both players return to play and

collect garbage.

## 4 Conclusions and Future Works

New technology has great potential to benefit education. From this example, it should be clear how important games can be for stimulating rapid re-mixing for educational examples.

This paper involved the development of a multiplayer serious game with several components: virtual reality, learning, crowdsourcing and affordance, among others. We described a serious game that was designed to motivate players to recycle properly so they can use it on his daily life at real spaces with waste sorting such as squares, public building, etc. The game was designed to be played by any player even without experience with games giving an interactive visualization experience and multi-RV interaction.

In this work we had focused on crowdsourcing learning and how to do it more natural and intuitive to users allowing proficient user-interactivity in real-time, meaningful feedback and learning through an interface.

The effectiveness of the game as a pedagogical vehicle can be highlighted by some influencing factors: social interaction, immersion, ambient noise level, among others [25]. By the moment, some game's aspects are beta version.

Future works will be oriented to improve game engine annoyances. Some environment issues, such as hardware platform, limited the scenario's resolution of the game. This constraint often forced a trade-off in the amount and nature of special effects and the number of textures used to create the game environment.

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