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AUGMENTED REALITY AND GAMIFICATION APPROACH WITHIN THE DIMMER PROJECT

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Abstract

Innovative learning methods as well as research projects dissemination can be achieved by digital technology. AR (Augmented Reality) can play a key role in the education field in order to transmit knowledge to young generations. AR is used to develop a playing cards game for children based on energy saving topics within the DIMMER (District Information Modelling and Management for Energy Reduction) European Project, where energy consumption awareness is one of its main aims. The DIMMER system enables the integration of BIM (Building Information Modelling), distribution network models, real-time data from sensors and user feedback through QR Codes and web portals. The energy performance of buildings is analysed from their actual utilization and especially from users' feedback. Despite pervasive sensors implementation is a necessary tool to monitor buildings, the more effective way to reach real energy saving is to pursue user awareness and promote good practices in energy using. In fact, energy information sharing has been intended as the main focus in the DIMMER game, since children can adopt good habits that will be reflected on adults behaviour. The game conception has been reached by the collaboration between Politecnico di Torino and Primo Liceo Artistico Statale, as well as the staging of a theatrical show about these issues. In this way a connection between University and High School has been established about current research topics and the uses of new technologies for pedagogical purposes. AR is investigated in order to promote an interactive game for children in which the differences between good and bad practices in terms of sustainability and energy efficiency are discussed. It indeed turns out to be an effective means of communication with immediate impact on children learning. Cards are characterized by markers which are linked to 3D models through a specific software that enables their visualization on personal devices in AR. In the game, natural elements that are capable to generate energy (sun, fire, earth, water and wind) define the seed of every card. Attractive and colourful figures are used to represent renewable energy sources and their applications, while dark images represent the most polluting solutions. The DIMMER game purpose is not to pick up the higher number of cards, but saving energy through positive figures, avoiding those that involve pollution generation. This kind of approach establishes an interaction between children and the energy problem by encouraging active learning through the game and raising their awareness. Children are stimulated by AR multimedia elements that make learning more interesting and entertaining.

Keywords: Augmented Reality, DIMMER Project, gamification, user awareness, energy saving.

1 INTRODUCTION

Nowadays in Europe energy consumption is one of the most discussed issues related to economic and environmental conditions. For this reason the Horizon 2020 Program [1] underlines the needs to reduce energy and to increase citizens' awareness on these topics. In order to achieve these objectives, the extended and integrated use of the Information and Communication Technology (ICT) potential allows correlating data, processes, systems and methods that are often very different from each other with the aim of making them available through new communication systems as the QR Code, AR [2]. The main goal of this action is to develop systems for displaying information related to buildings and their energy consumption. This information can be available in real time through personal devices and can be used both to empower users to save energy (students and tourists) and to optimize technical data management (by energy and facility managers or maintenance workers). In the smart cities and smart building contest user awareness is one of the main aspects and school represents a strategic hub to promote educational programs and involves the adoption of new lifestyles based on the idea of energy saving.

In this perspective these new systems are employed to communicate the purposes of DIMMER Project, funded under the Seventh Framework Program of the European Community. The project aims at optimizing the energy consumption in existing buildings and at urban scale by using ICT technologies in order to manage them, and by also considering smart grids and users' empowerment. The goal of this project is to develop an integrated BIM, based on 3D models at district urban scale where, due to the installation of sensors within the most significant buildings, data from the models can be managed in real time according to the feedback given by user's behaviour in terms of energy consumption.

The employment of technologies is not enough to turn a traditional building into a smart one because people consciousness is required for its utilization. The awareness-oriented phase represents a key point for the dissemination of this project and of its objectives, and it has been specifically exploited to establish a relationship between University and High School for children learning. In this particular work, AR has been intended to be a helpful tool to get a higher level of consciousness: it has been used by young students in order to develop a playing cards game and a theatrical show both based on energy saving strategies and related to the DIMMER Project.

2 METHODOLOGY

2.1 DIMMER Project's overview

The DIMMER Project is based on the main results of the Smart Energy Efficient Middleware for Public Spaces (SEEMPubS) Project which consists in developing a web-service oriented open platform with capabilities of real-time district level data processing and visualization [3]. The technologies that will be used and improved within this project will be: real-time data collection; advanced middleware technology for data integration; simulation and virtual visualization; user/social profiling, visualization and feedback; energy efficiency and cost analysis engine; web interface and interaction. The demonstrators of the project are located in Turin (Italy) and Manchester (UK). Focusing on Turin case study, Politecnico di Torino adjacent district has been chosen because it includes a wide range of building typologies, both private – residential – and public – schools, offices, etc. Moving from urban to building scale, different types of models have been developed and correlated between each other. From this point of view the use of BIM and GIS potentialities offer 3D data models able to provide information about buildings and their surrounding environment [4]. For this reason, the creation of a digital parametric model becomes fundamental since it includes information related to the buildings and, what is more, to their electrical power and thermal distribution networks. As visible in Fig. 1, different type of district and buildings data, like geometrical, historical and Building Automation Systems (BAS) outputs, can be collected and extracted in many ways for different users (i.e. children, students, workers, facility and energy managers, etc.). The same data can be visualized following various strategies and tools. For example, energy data can be displayed by the city/building energy manager to suggest more efficient policies, by residential users for costs saving calculations or by the instruction sector for arise young generations' awareness on sustainability issues.

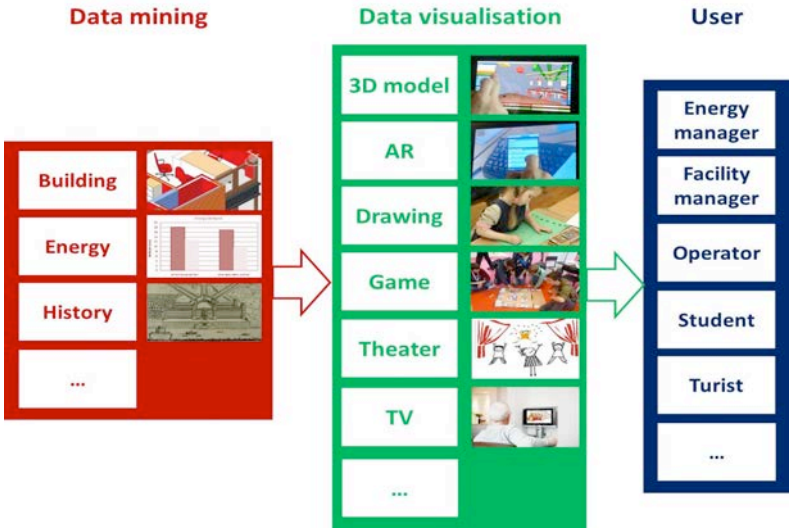

Figure 1 - Chart of the information flow from data to end users

In order to disseminate the methodology about 3D parametric models and sensors networks, different channels of communication have been exploited, including games and theatrical shows for children and young students (8-16 years old), who will be the future “Smart Users”. The goal is to improve awareness in a funny way, easy to be learned in everyday life. In order to enhance education in an optimal way, AR and Gamification have been combined for the creation of an energy saving “ECO card” game and of the “ToBeSmart” show, as described below.

The activities have been carried out by involving the students of Primo Liceo Artistico di Torino (High School) who got some classes and workshops about sustainability, energy saving strategies and AR; both the game and the theatrical show were conceived as the final result of the collaboration with Politecnico di Torino. Thanks to the coupled gaming/showing approach, awareness has been entirely reached, while the creative capabilities of teenagers have been stimulated by focussing on energy saving. Even younger children have been able to heed the importance of these topics by both playing the AR cards game and watching the show.

In the last years the AR technology has been introduced in many fields such as education, maintenance, manufacturing, medicine, business, public service, military, gaming and entertainment [5]. New technologies as Sony’s new mobile gaming platform "PS Vita", considered a good example and a best practice for the DIMMER Project dissemination, offer a more immersive gaming experience to a younger generation able to be more stimulated by interactivity, allowing a more efficient feedback and a faster assessment. Nowadays virtual objects containing text, graphics, video and audio can be made visible by using specific devices according to the Reality–Virtuality (RV) continuum approach [6], where real and virtual objects are presented together within a single display defining a generic Mixed Reality (MR) environment.

The introduction of technology in education becomes an essential support to engage and motivate them about specific topics [7]. In our case study this purpose has been reached by involving the students in the creation of 3D models and their related AR markers. The game has been conceived by using simple and not expensive technologies, as shown in Fig. 2. The base-components which are necessary to make the whole process work are:

- Hardware: personal computer, monitor or display screen, camera;
- Software: app or software running locally;
- Markers: physical objects or places where the real and virtual environments are fused together

The camera gets the information represented by each marker and by means of a specific software (AR Media) each tag is coupled with its respective 3D model realized with Autodesk 3ds Max Design. The Mixed Reality is then visualized on a display screen.

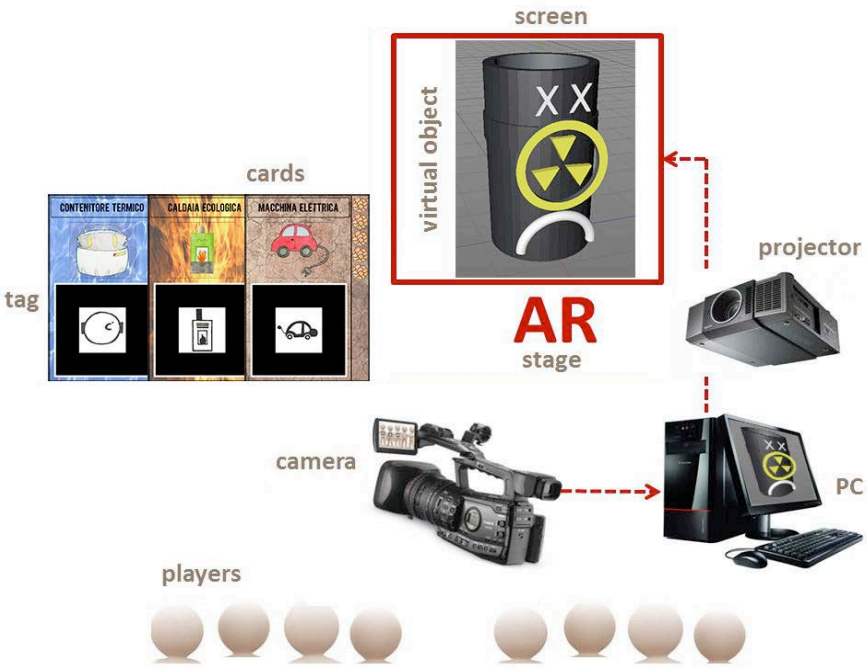

Figure 2 - Example of the use of the proposed technologies for a game

2.2 Gamification activities' overview

The main point of the game is the importance of clean energy generation, so the winner is the one who saves more energy and not the one who picks up the higher number of cards. In this way children learn easily to think to a long-term future and realize immediately the value of taking good practices instead of bad ones referring to their behaviour towards the environment. To allow this kind of working the game is composed by sixty cards organized into forty roles, ten bonus and ten 'energy element' cards. In Fig. 3 it is possible to see an example of every type of card, which are described below.

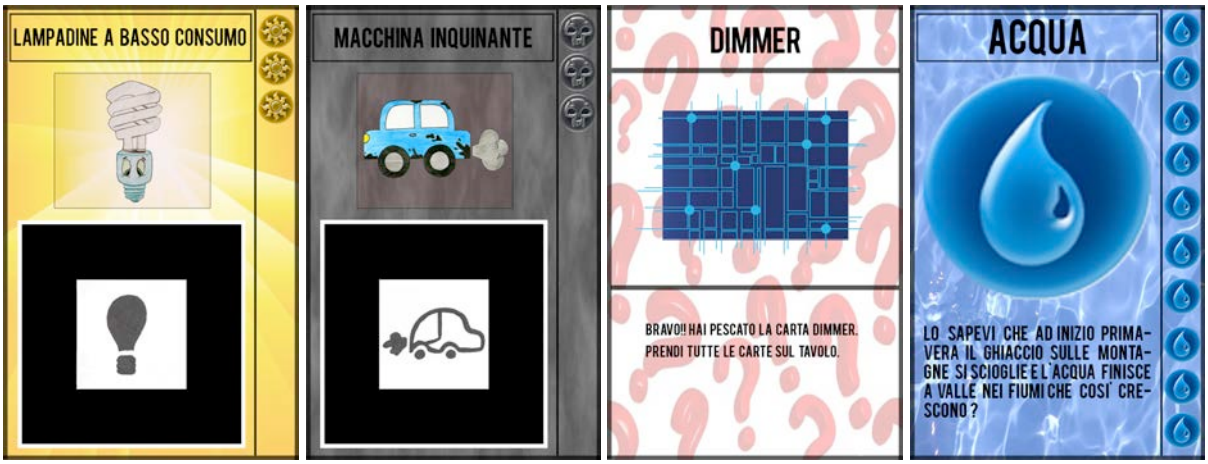

Figure 3 - (from left to right) Positive and negative role cards, bonus DIMMER card and energy element card.

The game is divided into ten turns in which an 'energy element' card establishes the dominant seed of each turn, with a maximum of two cards with the same seed. Since a limited number of fifty cards is provided, it is advisable to play the game with a maximum of five children. It is necessary to deal two bonus cards per child and the same number of role cards to everyone. The game starts from the younger child and it works counter clockwise. For every turn the children drop the card they prefer, paying attention to the dominant seed for energy saving, because its points will be stronger than points from the other seeds. It is possible to use bonus cards whenever the player wants – just one bonus card per turn – in order to take advantage in the game by changing the seed of the turn or playing another extra functionality, like picking up all cards or doubling points in the current turn.

Within role cards there are twenty-five positive figures that show different energy saving strategies, divided into five seeds representing the natural elements that are capable to generate energy: sun, fire, earth, water and wind. There also are fifteen negative cards related to elements that generate pollution to the environment. All role cards have points on them, in a scale from one to five, that will be determinant to the game's resolution: after every turn and at the end of the game, the points obtained by saving energy will be added whether points got by polluting practices will be taken off. The child with the higher score wins. In case of a hypothetical tie at a single turn or even in the final count, a three-question quiz about energy saving will be done to solve the situation.

It is important to notice how awareness in terms of sustainability is always present in the whole game contest: in addition to the perspective of winning by saving clean energy and refuting pollution, some advices or reminders are explained at the bottom of 'energy element' cards, in order to integrate learning at every phase of the game. As introduced before, the key element that allows to maximize the desire effect of children's consciousness is the use of AR by adding markers to the cards. Every single role card has a drawing on the top that represents a particular way of energy consumption (either positive or negative) and a marker on the bottom that schematizes it. The marker is linked to an appropriate 3D model that simplifies the energy element's icon of the card. While playing the game, a video camera gets the markers of the dropped cards, making 3D models appear on the screen according to the connection previously explained.

In the Fig. 4 below it is possible to see an example of this drawing/maker/3D model threefold representation. In this way the children will see the renewable energy sources they choose for playing represented by attractive and colourful 3D figures on the screen, while they will link up polluting solutions with ungraceful and dark images, understanding immediately the difference between good and bad approaches in terms of energy generation.

Figure 4 - Example of the threefold representation of the elements

AR enables children to learn in an interactive and entertaining way, so they get easily interested and motivated about relevant topics as energy consumption. This way they may become aware at an early stage of their lives, influencing their own habits and behaviours towards the environment and reaching even to affect the way of thinking of the adults around them.

For what concerns the theatrical show, developed by the students of Primo Liceo Artistico di Torino (High School), it stages the energy problem in an engaging and easy way to let little children concentrate and understand the importance of the topic. In order to include the idea of energy saving strategies within the world of building constructions, the play takes place in Turin and represents a discussion between an old building and a new one, both chosen among the DIMMER Project demonstrator. After an initial argument between them, the older building realizes to be too much polluting and it accepts the idea it is not a clean solution for the environment, allowing the building's administrator for its energy refurbishment in order to be transformed into a smart one, through an intervention of Politecnico di Torino.

As said before, the activities have been promoted as part of the DIMMER Project's dissemination, which represents the most important step to ensure the adequate implementation and sharing of the scientific progress. As shown in Fig. 5, this particular performance is part of the project's diffusion strategy, which aims to reach either the smart city's community or the educational sector through two different channels of communication.

Figure 5 - Overview of the DIMMER Project's dissemination strategy

3 RESULTS

The DIMMER Project aims at motivating people to care about energy reduction by data monitoring, letting them to manage and visualize information through their personal devices – i.e. smartphones or tablets. A technical system based on ICTs has been developed in order to manage both the energy data coming from sensors and the Building Management System (BMS) through an interoperability process [3]. Fig. 6 is useful to understand how the ICT is used by the DIMMER Project for collection, management, sharing and visualization of data needed to fulfil the district information platform in the cloud system. The level of development of this research can be visualized reading the chart in a vertical way. In this context the exploitation of technology aims at introducing citizens into the energy saving field and at making them an active part of smart cities by improving their environmental consciousness and their behaviour.

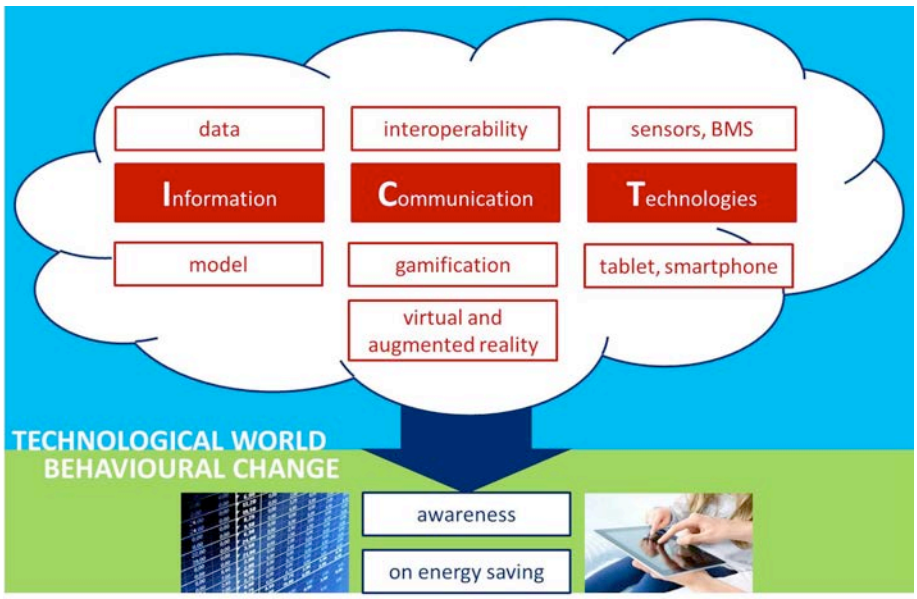

Figure 6 - The technological world for a behavioural change

The application of the behavioural change among the young generation can be possible by introducing innovative technologies in the educational sector and by connecting the latter to the research field. Nowadays, teenagers use technology in a very intuitive manner. This approach simplifies their assimilation of concepts and allows them to have fun while learning about energy usage. As a result, the students of Primo Liceo Artistico have transferred the classes and workshops contents into the children's cards game and the theatrical show described before. Energy saving strategies and air pollution reduction have been promoted at different levels of awareness in a simple and friendly mode to make all generations smarter. Due to the wide range of existing immersive games young people usually prefer to play within a new virtual environment instead of playing in a conventional way. For this reason, a re-elaborated version of traditional games has been carried out with the introduction of multimedia content through AR in order to attract them. Consequently, a link between traditional games and innovation has been created for the involvement of different generations on issues that currently play a key role at a worldwide level.

With the participation at the “Researchers’ Night 2014” event in Turin, the achievements previously mentioned and an actual dissemination of the project have been pursued. For this occasion an eight-hour contribution that involved both gaming and theatrical staging has been performed by Politecnico di Torino and Primo Liceo Artistico. The available time was dedicated to both the gaming and the staging part by spacing out the cards game with the thirty-minute show played by the students in front of a children audience. Despite the periodic breaks from gaming, the learning experience was not interrupted but rather continued during the show thanks to the funny discussion between a poor energy efficient building and a smart one. This way sustainability was always the protagonist of the evening and consciousness was reached through two different ways of dissemination.

In order to know the extent of the intervention, data from the event have been studied and compared with results from another traditional game which was tested in a similar contest previously: an

innovative version of 'Game of the Goose' with multimedia content using AR – from now mentioned as 'SEEMPubsdicE' game [8]. For what concerns the gaming part of "Researchers' Night 2014" event, 80 people were involved, of which 76 children – with an average age of 13 years old – and 4 adults. Although DIMMER cards game was developed for children use, the percent of adults participation reported on Fig. 7 demonstrates that a family involvement on energy awareness through gamification is possible.

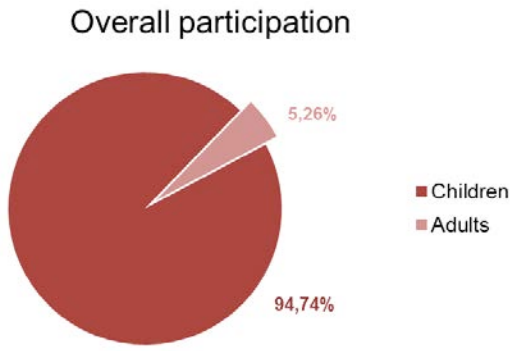

Figure 7 - Distribution of overall participation on DIMMER cards game

Considering that every single game is reduced to five people, the total amount of participants were able to play a sum of 16 games during the entire event. Regarding to the collected data, they give an approximate duration of 20 minutes per game including the explanation of the rules. Comparing the performance of the year before, the 'SEEMPubsdicE' game involved 143 people – of which 137 children with an average age of 10 years old – distributed into 39 games of 12 minutes each. In Fig. 8 it is possible to see a graphic that schematizes this comparison.

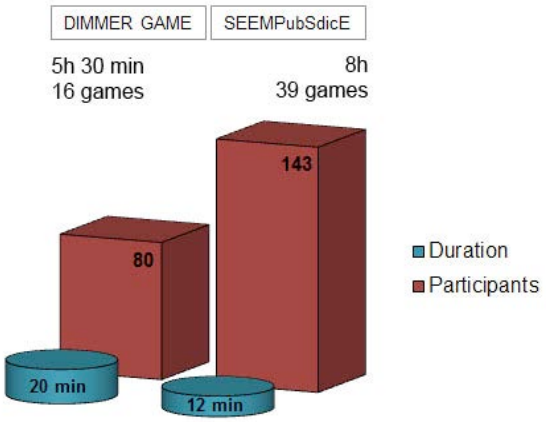

Figure 8 - Comparison between DIMMER and SEEMPubsdicE games in terms of duration and number of participants

After analysing the collected data, how real capability of dissemination is influenced by the duration and the easiness of the different games has been noticed; these will be aspects to take into account for future works related to gamification. The second experience confirmed that an approach to education through the game gives very good results, corroborating the educational value of AR and extending it to its capacity to optimize the communication process.

4 CONCLUSIONS

AR has turned out to be a relevant achievement for the development of smart cities when used for dissemination, becoming part of a complex process that requires an interdisciplinary strategy of all parties involved, allowing for a simple and optimal way to disseminate. Taking into account the importance of adapting methods to the particular end users, employing the appropriate technologies for each case becomes fundamental. For this reason our aim is to continue developing the application of AR and its technologies to create alternative ways of teaching, in order to make learning more

enjoyable and productive for students. Gamification and theatrical showing are interesting tools that can be easily exploited through AR to stimulate children's creativity and critical thinking. At the moment these two mechanisms represent just an early stage on the DIMMER Project's dissemination strategy but have already shown they shape a reliable educational approach –in Fig. 9 the difference between a game-based education and the traditional one has been represented. Their profits have been checked out by the success of "Researchers' Night 2014" event, which has given an extra impulse to our team for future developments and researches on the field.

Figure 9 – Difference between a traditional and a gamified education

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