Using the Learning Mechanics – Game Mechanics (LM-GM) framework for the design of serious games for teaching photovoltaic systems

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1 INTRODUCTION
The use of new communication and information technologies in an educational context facilitates new modes of teaching and learning interactions to engage and challenge the current generation of young adults, who have grown up as digital natives, comfortable with the adoption and use of a range of technologies in their everyday lives [1]. In this context serious or applied games, usually defined as computer games used in training which include educational elements and the appropriate use of multimedia resources with some entertainment value can be useful [4]. Well-designed educational/serious games can be effective teaching and learning tools that can both engage and entertain students. This is increasingly important given the challenges from other media formats for students attention e.g. videos and have the potential to motivate students and increase their levels of interest in topics that are traditionally perceived as difficult and hard to comprehend [2], [3]. This game category is increasingly used successfully in a broad range of application and domain areas e.g. medicine, engineering, cybersecurity and business [5]–[8]. In the engineering domain numerous examples of this type of approach can be found. The Circuit Warz project uses a game based, competitive approach to teaching the fundamentals of electronic and electrical circuit theory with a high level of replayability and entertainment value [9]. This research project focuses on assessing the effectiveness of using a similar game based approach in the design of games to teach the operation and maintenance of photovoltaic systems with a view to making this subject area and career path more attractive to students.

2 MOTIVATION
The educational sector continues to evolve to meet the needs of students as the impact of new technologies on the sector becomes more apparent and pressing. This evolution requires the rethinking of some traditional approaches to teaching and learning in terms of creating engaging experiences for students through maximising the opportunities for new forms of interactions offered by new and emerging technologies [1]. In addition to this there is increasing demand in some sectors for suitably qualified professional engineers and technicians, particularly in photovoltaic systems in the Brazilian market where there is a skills shortage as the country seeks to maximise the opportunities offered by solar power and increasing energy demands world-wide [10]. The use of serious/applied games in this context to engage, motivate and train the next generation of photovoltaic engineers and technicians is the main focus of this research.

3 RELATED PROJECTS
The following sections reviews relevant projects in this and related areas with a focus on the use of 3D Virtual Worlds and Serious Games.

3.1 Studying in 3D Environments (rev. 2014)
MARCELINO et al. discusses the use of virtual worlds for teaching in public schools and the subsequent impact of the project undertaken on changes to teaching approaches and the way the curriculum is presented and concludes that the use of 3D virtual worlds in this environment can provide an efficient and stimulating learning experience for students [11].

3.2 3D virtual worlds using open source platforms with integrated remote experimentation. (2012)
MARCELINO et al explores and demonstrates the practical use of 3D virtual worlds in the teaching/learning process in the area of exact sciences using a remote experimentation/virtual simulator approach. A 3D virtual world was created using OpenSim environment which integrated the virtual environment with an electrical remote experiment on real equipment [12].

3.3 Mapping Learning and Game Mechanics for Serious Games Analysis in Engineering Education (2017)
CALLAGHAN et al presents an approach to the analysis and design of serious games using the Learning Mechanics – Game Mechanics (LM-GM) framework to teach fundamental electrical and electronic circuit theory. The project focussed on the use of game mechanics to increase levels of student’s engagement and knowledge retention in engineering disciplines [9].
4 Proposed Solution

This research is focused on the development of games and simulations to teach elements of the curriculum related to the training of technicians, electricians and engineers in the field of photovoltaic systems using a serious games approach. It includes an evaluation of the approach taken in terms of improving the students learning experience and increasing their levels of engagement and motivation.

4.1 Game Design, Analysis and Modelling

The photovoltaic systems serious game developed will be analysed and designed in a formal fashion using the Learning Mechanics – Game Mechanics (LM-GM) framework [13]. This framework provides a structured approach to mapping learning outcomes to the appropriate game mechanics to ensure the game is validated and that the students meet the intended learning outcomes in a way that is quantifiable. The backstory for the game and player motivations /objectives will be designed using the Heuristic Framework with embeds story elements into the overall game narrative [14].

4.2 Serious game development and implementation

When the design, analysis and planning phase is complete the game will be developed using Blender for the content creation process and modelling. The initial game will have three different stages created in a 3D virtual world that will allow students to learn, develop and apply their knowledge of photovoltaic systems.

4.3 Game’s integration in an on-line course

When the game is completed it will be integrated/embedded as a learning object in an on-line course hosted in the Moodle Virtual Learning Environment. This approach will allow the students and technicians to apply their theoretical knowledge of photovoltaic systems practically in a range of simulators.

4.4 Impact evaluation

To evaluate the game and its impact on the learning process, a questionnaire will be sent to selected students for feedback on their experience. This feedback will to cross referenced with in game analytics which measure actual game usage.

5 Preliminary Results

The game is currently in the design/analysis process using the LM-GM and heuristic frameworks. From this a Game Design Document (GDD) [15] was created which defined the games aesthetic, main mechanics, characters and plot line. During the game the player must apply their knowledge of photovoltaic systems to repair and maintain three energy generating photovoltaic plants in a range of different scenarios with different learning outcomes and objectives.

6 Conclusion

As new technologies continue to emerge and disrupt the educational landscape it is essential that educators learn to fully embrace the opportunities offered and find new ways and approaches of interacting with students in an effective and measurable way to meet the challenges the planet faces in the 21st Century. In this context the use of serious games which are well designed and validated using formal frameworks can be used to engage and motivate students. This project will focus on some of these challenges through the creation of a serious game for teaching and learning in the area of photovoltaic systems. The subsequent evaluation will measure the level of improvement to the student learning experience and challenges involved in the approach taken.

References