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Design methodology for educational games based on graphical notations: Designing Urano

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ABSTRACT

Serious games, especially educational games, have proliferated in the last decade, with many proven benefits. However, there are very few methodological proposals for educational video game development, and the proposals analyzed in this paper display certain drawbacks that limit their application. This article therefore presents a new methodology for developing educational games based on graphical notations and divided in six phases: design of chapters, design of scenes (scenarios, characters, actions and dialogues), design of educational challenges in the game, design of the adaptation, design of the emotional experience and design of collaboration. This methodology seeks a balance between the overall and the detailed view required to create the game. In order to achieve this, the methodology moves between different levels of abstraction and deconstructs the process into phases and steps that structure this complex task and which can be understood by non-technical members of the multidisciplinary team. The methodology is applied to a video game that is currently in development and serves to illustrate the proposal. Furthermore, important concepts when designing the narrative of the story of the game and to evaluate it, including the expected emotional reactions, are discussed in this article.

1. Introduction

The game, understood as a pleasurable activity, is as old as man. From our birth we play, and that is the way we practice certain physical, cognitive and social skills. The electronic games or video games are no different. Leaving aside the different genders of video games and the multiple media where they can be presented, all games have a number of common features (e.g. high interactivity, fun, rules that the player must follow, scoring system or a competitive factor). On the other hand, the capability of the game to exercise our bodies and minds can be exploited. This is precisely what happens with serious games. Serious games [1,2], are not only aimed at providing entertainment but also at exploiting these in order to work areas such as education, public policy, health or communication strategies.

It is a fact that since 2007 there has been a considerable increase in the scientific production in serious games. A thorough search of scientific literature on serious games from 1990 to 2012 revealed that 54% of papers on this subject were published in the period 2007–2012 [3]. Another relevant fact is shown by Vargas [4] who states that in a systematic search, 60.71% of serious games belong to the educational sphere. These results might be explained by problems such as dropping out of school due to lack of motivation; and educational video games (also called educational games in this paper) could provide that missing motivation, becoming an excellent tool for instructors and parents.

Correspondingly, many studies underscore the advantages of using video games in education [5–7] since they reduce reaction time, improve hand-eye coordination, increase self-esteem, improve spatial conception (manipulating objects in 2D and 3D, rotation plans, etc.), encourage interactive learning, motivate learning through challenges, stimulate exploratory behavior and the desire to learn, permit simulators so that users can practice without any real consequences, improve social skills and basic math, articulate abstract thinking and improve cognitive skills (e.g. strategic planning, multiple learning styles, etc.), among others.

Thereby, once assumed the benefits of using educational games (properly raised and exploited), our aim in this article is to highlight the shortage that still exists of specific methodologies for designing educational games. These methodologies must be con-

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ceived by non-technical personnel (including educators, writers and artists) to be used by software developers. Accordingly, we propose as main contribution a methodology to address this deficiency. The distinguishing characteristics of this methodology are the specification of a structured sequence of steps, the use of a graphical notation to the design artefacts, and the inclusion of adaptation and collaboration aspects during the design of the game.

The rest of the article is organized as follows. Section 2 outlines the current state of methodologies for designing the video games and educational games. Section 3 describes our approach in an attempt to reduce the previously identified disadvantages and explain the phases of the proposal methodology with a video game currently being developed according to it. Then, Sections 4 and 5 focuses on the design and evaluation of the narrative and emotions in the game. Finally, Section 6 presents our conclusions and the framework for the application of the proposed methodology.

2. Related works

Development methodology refers to a series of techniques and/or processes by which a video game is developed. While it is possible to develop a video game by following various general software methodologies (e.g. the waterfall model, the incremental or the agile method, etc.), game development generally consists of three phases: pre-production, production and post-production based on the film's life cycle [8,9]. Our interest, however, lies in the development of game-specific methodologies on which not much has been published.

Some methodologies and processes reviewed are outlined below.

2.1. 5M methodology for games

The 5M classification is often used in the engineering industry and can be applied to video game development as follows [10]:

- *Method*: general organization of the different production steps, including the inflow of material production and the intervention of human actors.
- *Milieu*: all the elements involved in serious game production, for example domain experts (teachers, doctors, engineers, etc.), independent subcontractors (sound technicians, graphic designers, etc.) and students and tutors (testing and feedback).
- *Manpower*: the team of human actors involved in the production chain. For reasons of comprehension, these actors are described by their roles (pedagogical expert, programmer, etc.) although these roles can be assigned to a single person.
- *Machine*: set of tools that help the human actors produce the serious game.
- *Materials*: documents, prototype models, executable files, databases and other devices used to produce the final serious game.

Although 5M methodology proposes an interesting production process for educational games, it is unsuitable from the point of view of Software Engineering.

2.2. Methodology based on Westera levels

This approach combines three different levels [11] for the system integration, framework and structure of the video game:

- On a *conceptual* level, a game is considered to be a system (i.e. a set of interrelated elements). A game is designed by specifying certain relevant factors, taking into account the two fundamental dimensions of space and time: the space dimension covers the static configuration of gaming locations (virtual) and includes associated objects, attributes and relationships, and its evolution over time covers the game dynamics.
- On a *technical* level, the framework describes the basic architecture of the game development system which describes the system and its tools for developing the places, objects, actor roles and scenarios of the video game.
- On a *practical level*, i.e. the structure of the game, the options offered to the players and the multimedia representation of the game environment.

This methodology offers a significant improvement with respect to the efficiency in the design of serious games based on scenarios with simple graphics; but the proposed methodology does not include graphical notations or collaborative design.

2.3. SUM methodology

SUM is an agile methodology for game development that adapts the Scrum structure and roles [12]. SUM suits small multidisciplinary teams (three to seven components) and short-term projects (less than a year). The methodological definition is based on SPEM 2.0 (Software and Systems Process Engineering Metamodel Specification). The main advantage of SPEM is its flexibility and adaptability since it is not necessary to mention specific practices.

- Roles: The methodology defines four roles: development team, internal producer, customer and beta tester.
- Life-cycle: This is divided into iterative and incremental phases that are executed sequentially, with the exception of risk management, which is performed throughout the project.

The SUM methodology is directed towards video games in general and has been defined for small projects, hence it is not suitable for the purpose of this study (although it might be supplementary considered).

2.4. Ontological methodology

In his work, Llansó et al. [13] outlines the problems common to game development and focuses on the uniqueness of the multidisciplinary team that is usually involved (e.g. the artists, designers, programmers and in the case of serious games, all manner of professionals) and this can sometimes result in the breakdown of project communication. By way of solution, the methodology proposes the ontology as a basis for communication whereby the designers are solely responsible for describing the characters, objects, functions and status of the run of play and the programmers refine the technical details and objectives. In this way, they are working on different views with the same information.

However, the proposal is not restricted to serious games (and possibly this type of video game should be disregarded) since the main focus is on facilitating communication ignoring other difficulties which are inherent to the design itself. In addition, the ontological syntax may not be intuitive or natural for non-technical staff.

2.5. Design process based on Padilla-Zea models

The game is defined by a series of models generated during the design process [14]: educational content models, entertainment content models, models for the interrelation between the educational and the entertainment content and user models for adaption. This approach emphasizes the relationship between