Designing educational games: key elements and methodological approach

Rafael P. De Lope, Nuria Medina-Medina, Rosana Montes Soldado,Antonio Mora García and Francisco Luis Gutiérrez-Vela
Research Centre for Information and Communications Technologies
University of Granada (CITIC-UGR)
C/ Periodista Rafael Gómez Montero 2, 18014. Spain
Email: rprieto@ugr.es, nmedina@ugr.es, rosana@ugr.es, amorag@genera.ugr.es, fgutierr@ugr.es

***Abstract*—Serious games, especially educational video games, have proliferated in recent years. Despite this, there are very few methodological proposals capable of addressing the design of all the key elements of an educational video game. To deal with this discrepancy, this paper presents a methodology divided into five phases: startup, design, production, test, and post-production; focusing on the design phase of educational games. The design phase structures an educational video game in acts, scenes, scenarios, actions and dialogues; and defines the modeling tasks and generated artifacts which have to be carried out in each step of the process.**

***Keywords*—video games; educational games; design methodology**

I. Introduction

Many studies highlight the positive effects of playing games [1], and not only for children but also for adults [2]. Thus, to play a game is and must be linked to man's existence, and it is not surprising that the first electronic game appeared six years after the first computer [3]. More specifically, the video game was created in 1947 by Goldsmith and Ray [4] in a cathode ray tube and consisted of a missile simulator used in World War II. It was indeed the recurrence of violent themes in the first video games that was responsible for giving the video game industry a bad name due to the possibility of encouraging violent behavior or "electronic autism" [5]. Fortunately, numerous studies quickly showed that these problems were due to game misuse and in particular to inadequate game design. For example, in the article by [6], play is presented as a "mediator for the construction of social identity and the acquisition of new skills associated with 21st century literacy". Today, it can be said that this 180 degree change in outlook has still prevails, with a proliferation of proposals for maximizing the benefits of play in different contexts. According to [7], some of the benefits derived from the use of most video games include greater resilience, better motor coordination, increased self-esteem, improved spatial conception, greater motivation, stimulation exploratory behavior, acquisition of social skills and also languages. Even violent games, when properly used, can help to relieve stress [8].

In the last years, video games for a serious purpose (also called serious games) [9-11] have been emerging in various diverse areas like health [12] and education [13], along with others such as business [14]. Particularly, education is one of the most prolific areas in serious games [15], which can also be referred to as educational games or serious educational games. However, there are not many specific methodologies for educational video games that allow the design of all the key elements in this type of games to be managed. Often, the participation of the educational team is not contemplated, and an adequate balance between the educative part and the ludic part is not achieved, which results in a reduced quality game [16, 17]. Consequently, this paper is organized in the following way: Section 2 summarizes the related work. Section 3 focuses on detailing a proposed methodology to create effective educational video games; and finally Section 4 outlines our conclusions and future work and research.

II. Related Work

There are several works on video game design [18-21], and everyone agrees on the difficulty that this task entails. A recurring question in all these works is whether the video game is fun, in fact there are authors as Koster [19] who defines fun as "the act of mastering a problem mentally" and a theory of fun for game design is developed accordingly. Salen and Zimmerman [18] propose a design schema to provide a useful conceptual lens for game creation and analysis. Moreover, those authors define aspects such as: game rules [18], play testing [20] or the figure of the designer and his creative ability, in addition to his role within the development team [20, 21] as keys to the success of a game. Although all these works are more than interesting and many of their guidelines and reflections are applicable to the development of any video game, they are not as specific about educational games.

Moreover, although they are also focused on video games in general and not on educational games, there are several works that propose some life cycles to develop video games. All these proposals are collected and analyzed in an interesting work by Ramadan and Widyani [22]. These proposals have some points in common, such as the phases which are considered for the development of a video game (design, production, testing or post-production), and although they denominate it in a different way, these proposals differ in the approach of their life cycle, as McGrath [23] and Chandler, or the work of Ramadan and Widyani [22] follow an iterative and incremental model, while Hendricks [24] or Blitz Games Studios [25] are closer to a cascading development. The methodology presented in this paper follows a life cycle similar to that proposed by Ramadan and Widyani [22], a proposal that emphasizes the importance of performing different iterations in the design, production, and testing phases.

Regarding the design of educational video games, there are great efforts to improve this type of video game. For example, Hirumi and Stapleton [26] identify the existence of a problem between pedagogues and game developers: the distribution of tasks should be balanced to achieve a quality game, that is, it has to be fun and also useful as a pedagogical tool. As a proposal solution, they establish a detailed description of tasks aimed at educators --to facilitate the relationship of the tasks of game developers-- and the tasks that correspond to educators. They follow a spiral development methodology consisting of three phases: conceptual, pre-production and production. Although this work can help educators to best participate with the technical team, this study does not propose a new methodology to develop or to design educational games, but rather adds the tasks of educators into a standard cycle of software engineering.

Another interesting study was carried out by Bjørner and Hansen [27] which proposes a series of attitudes concerning some design principles for educational games, such as: (1) the problem of how to cover the curriculum, (2) the need to motivate the student and how to deliver high quality learning, (3) poor technical skills in teachers, (4) overcoming the difficulty of using collaborative tools for working groups, and 5) the quality of the game title. These principles are arrived upon as a result of the study on the state of the art and a series of surveys conducted on teachers, game designers, and students. It is interesting to highlight some aspects that the authors consider relevant when designing educational games, such as the balance between the playful and the educational elements, and the technology gap that usually exists among teachers and the technical team. However, as in the case of Hirumi and Stapleton [26], they do not propose a methodology that really allows the technical team to work with pedagogues.

Literature brings a conceptual model that facilitates the design of educational games [28].The model is represented by an UML class diagram that allows its later implementation with any programming language. This model combines key concepts of video games (music, game design element, plot, characters…) along with educational concepts (learning, learning outcomes, curriculum), together with their relationships (i.e. goal→level→learning outcome). In addition, this model is implemented as a web application to facilitate its dispersion. Although the model may be useful, it only allows the designing of educational games superficially, not being able to go into deep details. Even so, its usefulness as initial design or starting point of an educational game is undoubted.

Up to this point, though there are studies that propose design guidelines or even models to design video games or educational video games, there are not many studies in scientific literature which describe a methodology for developing educational games, in line with Arnab et al. [29], nor is there an abundance of guidelines, models or methodologies to design educational games. Nevertheless, when an educational game is developed, it is essential to integrate a set of specific elements in the game, many of which will be provided by a team of educational experts. In this way, the usual cycle used in video games (pre-production, production and post-production [30]) must be modified. It is exceedingly important to involve educators in the process in order to achieve quality educational design and well-balanced educational challenges in relation to ludic challenges. In line with this way of thinking, authors such as Padilla-Zea, Medina-Medina, Gutiérrez-Vela and Paderewski [31] or Arnab et al. [29] recognize the importance of balancing both playful and serious components in defining their conceptual models, but their work does not include graphical notations (which is an essential aspect in facilitating inter-disciplinary communication [32, 33, 34], and does not consider how serious components are integrated into the narrative structure of the game.

Another interesting approach is SUM [35], which is an agile methodology for video game development that utilizes Scrum structure and roles [36], and defines several sub-roles for managing some specific tasks of the video game design, for instance: sound engineer, graphic designer, or game play designer. In addition, a new role is added: beta tester. Regarding the life-cycle, SUM adds a phase not considered in Scrum, the concept phase, which defines the elements of the game (characters or story), business model, and technical aspects (language, framework, etc.). SUM is normally applied in small multi-disciplinary teams (three to seven people) and short-term projects (less than a year); and defines four roles: development team, internal producer, customer, and beta tester. Its methodological definition is based on SPEM 2.0 [37]. The main advantage of SPEM is its flexibility and adaptability since it is not necessary to mention specific practices (for specific tasks or in specific areas). SUM methodology is limited to small projects and it focuses on general video games, rather than educational games. In addition, although the authors describe the methodology correctly, they do not detail the artifacts generated by the design process (documents, diagrams, or prototypes).

In their methodology, Marfisi-Schottman et al. [38] propose to generate the educational game following the five steps of the engineering industry (Method, Milieu, Manpower, Machine and Materials). The tasks are perfectly assigned between the various roles which are present in the development of serious educational games (graphic designer, sound manager, designers, pedagogical experts, programmer, cognitive specialists…). However, pedagogues are consulted in some considerations, but not sufficiently included in the process. Finally, there are other interesting works but they are very specific; such as the Emergo methodology [39], based on ADDIE (Analysis, Design, Development, Implementation and Evaluation) and directed at higher education, or the design guidelines presented in [40], focused on the design of serious games aimed at children with autism.

Of all the proposals analyzed, the authors have not found any aimed at educational games which structure the game in such a way that it is relatively easy to implement the game through diagrams (acts, scenes, scenarios, actions, or dialogues), and in reality it is these diagrams which facilitate the communication between pedagogues and technical equipment. Hence it is fundamental to involve educators in the design phase.

III. METHODOLOGY FOR DEVELOPING EDUCATIONAL GAMES

The proposed methodology aims to develop educational games in which the story plays a major role. Therefore, it is especially appropriate for the development of educational adventures, but could accommodate other game genres which are associated with educational games (i.e. shooting or fighting games which may seem that they are not well suited to improving educational skills). In any case, the methodology has not been tested with other genres, so it would probably be necessary to make adaptations.

The methodology arises from four key pillars: (1) the GEDES research group (to which the authors belong) have more than ten years of experience in developing games [41], of which many have been educational. (2) The analysis done by the authors of the state of the art on the design and develop of games, and educational games [42]. (3) The application in part (design phase) of methodology in the development of an educational game titled *Uranus*: *The invasion of the thieves of planets* (hereafter *Uranus*). (4) The collaboration of game development companies such as VirtualWare group [43] or Greyman SL [44], this last, responsible for the implementation of *Uranus*.

The methodology seeks for an iterative and incremental approach that allows the generation of agile prototypes following five phases. Fig. 1 summarizes graphically these five phases of the methodology.

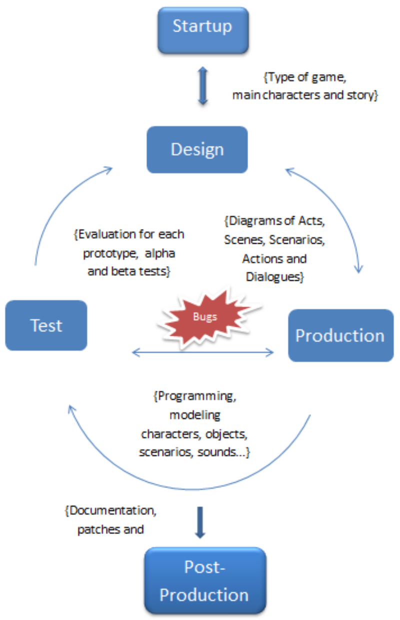

Fig. 1. The five phases of methodology to develop educational games.

- *Startup*: In this initial phase, concepts such as the type (action, strategy, logic…) of video game, educational skills to acquire, and a first design of the game story (and its main characters) are defined and refined. This will help to concrete the project scope, size, target clients, and so on.
- *Design*: In this phase, the game is structured in acts, scenes, scenarios, actions and dialogues. These elements are based on theatre plays (according to [45]) and are detailed in section 3.1.
- *Production*: Using all the artifacts (documents, prototypes, or diagrams) generated in the design phase, and the tasks of programming, animation, and modeling of characters, objects and scenarios, as well as the synchronization of sounds are carried out.
- *Test*: As in the vast majority of software development methodologies, it is necessary to plan and conduct a set of tests to verify, in this case, the performance of the video game. During this phase, prototypes are generated for further evaluation.
- *Post-production*: This phase deals with patches or updates needed to correct and improve the game after its publication.

IV. Design Phase

The design phase is a crucial phase in game development, which follows the initial phase (startup). Other authors such as Arnab et al. [29] also highlight the importance of the *design* phase when an educational game is being developed. Therefore, when the design phase starts, a series of the game's generic characteristics have already been defined. These features include the game genre (action, adventure, logic, strategic, sport, etc.), avatar control, platform (console, PC, smartphone/tablet…), target users, narrative level [46], area of application (education, health, government, marketing, etc.), and interactivity as active, pervasive, or standard [47] among others. These features were detailed in a taxonomy for serious games developed by the authors in [42]. In addition, during the initial phase, the general story of the game is written, as well as the main educational challenges to address in the video game. Based on these previous decisions, the design phase proposes a set of modeling tasks, which results in a set of design artifacts.

This design methodology has been instantiated in the development of *Uranus*. The game is a 2D adventure game whose goal is practicing Spanish reading comprehension, where the players (primary school children) must travel back in time and meet some historical characters (e.g. Cleopatra or Julius Caesar) to get a set of objects needed to save the planet.

A. Key elements

In order to perform the design phase, the following key elements must be addressed:

- The structure of the game, as mentioned above, is a metaphor of a theatre play with the following organizational elements:
  - Act: each one of the main parts in which the story of the game is divided. There must be at least one act; but there could potentially be several.
  - Scene: each act is divided into scenes, as in theater plays, and following their same structure, there are presentation, development, and denouement scenes for each act.
  - Action: each scene is divided into actions. The actions describe all the events present in the video game story. The action may have associated educational challenges (as will be explained below).

- Dialogue: a special type of action corresponding to any conversation that occurs between the game characters.

- *Scenario*. A 2D or 3D space where the scenes take place. There is not a direct correspondence between scenes and scenarios, so several scenes may take place in a scenario, or a specific scene can imply a change of scenario.

- *Characters* that are involved in the scenes and perform the actions and dialogues. Both the characters' physical appearance and personality (qualities, abilities or other considerations) have to be designed. Normally, there will be a special or main character, who will be the protagonist of the game (player's avatar). Depending on whether the game is narrated in first or third person, the avatar will have a physical presence or not.

- *Interactive objects* or active parts of the scenarios. These objects have associated some functionality and, in many cases, they can be collected by the player and incorporated into his/her inventory. These objects will be further used in the actions.

- *Educational competences* which represent a set of skills and attitudes in a particular context or concrete curriculum. For example, the Spanish education system defines eight basic competences [48], some of which are: linguistic communicative competence, cultural and artistic competence, or mathematical competence (among others).

- *Educational challenges* designed by the team of pedagogical experts. They will allow certain competences to be developed within the educational curriculum of the target students.

- *Sounds* that includes all the necessary acoustic assets of the game: voices, effects, and music.

- *Game play* or the set of game rules, a concept intrinsically related to game genre that defines the way in which the player interacts with the game mechanisms in order to accomplish the educational objectives, and to provide a fun experience which satisfies the player.

- *Adaptation*, understood as the ability of the game to automatically adjust itself to the player. Its design involves deciding what features of the game are configurable depending on the player's profile, such as: method of interaction, educational challenges and their assessment, and the narrative.

Fig. 2 shows the avatar just before picking up (action) the hammer (interactive object). In this case, a boy (can be adapted to be a girl) appears in a scene of the Roman act. This scene happens in an outdoor (scenario) where the player should overcome some challenges (e.g. to repair the chariot). This ludic challenge has associated an educational challenge with two educational competences: Literal Comprehension and Inferential Comprehension, as the player should be able to interpret the instructions of the old man to repair the chariot and infer that the wood of the chair can be used for this reparation (the hammer is needed to obtain the wood).

Fig. 2. Scene where the chariot must be repaired.

B. *Modeling tasks and artifacts generated in the design phase*

After the description of the key concepts, modeling tasks and artifacts that are generated at every stage of the design phase will be covered in this subsection. The first stage in the design phase corresponds to the design of the acts (summarized in Fig. 3). At this stage a breakdown of the story of the game in acts will occur, and the flow of the action through these scenes is decided. The result of this task is reflected in a design document called diagram of acts. In addition, an informal description of each act is performed. In *Uranus* there are nine acts, of which four are jumps in time to different epochs (Greece, Egypt, Rome, and Granada).

For each one of the acts included in the diagram of acts, the design of the scenes and the design of the scenarios are performed (normally, these two stages are conducted together). This is usually done incrementally, i.e., starting with the first act and progressing following the relationships defined between acts in the diagram. But the design of the acts could also be planned in a concurrent way, both if the capacity of the development team allows it, and if there are no dependences between acts. Thus, it is mandatory that the requirements to be met by every act are sufficiently specified.

The design of the scenes involves deciding what scenes have an act (or several acts) and the game flow between these scenes; therefore this represents a more detailed level of the story's breakdown. The result of this task is a diagram of scenes, together with an informal description of each scene and a supplementary table (which lists the scenarios and the main characters in each scene). In addition, at this stage, educators can associate a set of educational competences (selecting among those established in the Startup phase) to every scene, which the game will compel future players to acquire. In the case of *Uranus*, the act of Rome has a total of twenty-five scenes. For example, Fig. 2 shows the scene of *repair chariot*. This is the first scene of the act of Rome.

The design of the scenarios involves deciding the concrete set of scenarios used for every act, and which conditions must be met in order to move from one scenario to another. The result is documented with the diagram of scenarios. It is complemented with an informal description of every scenario (which may include graphic sketches) and a supplementary table which depicts the scenes that occur in this scenario and the interactive objects present in it. In the same act of Rome, there are ten different scenarios (refer again to Fig. 2), and one can observe the scenario where *repair chariot* scene takes place in the scenario: *country estate*. In this case, the number of scenes and scenarios are the same, but it is not always necessarily so. For example, in the dungeon scenario the authors have four scenes: *visit Julius Caesar in prison*, *back to the prison to see to Julius Caesar*, *back to the prison with banner* and *back to the prison with the blessed banner*.

Then, for each one of the scenes in the diagram, four steps are performed: (1) design of the characters in the scene, together with the design of interactive objects in every scenario of the scene, (2) design of the educational challenges that are going to be addressed on the scene, (3) design of the actions that take place in the scene, and (4) design of the dialogues between characters.

Firstly, in the design stage of the characters, the main characters established in the startup phase are modeled. All the characters that participate in the scene must be specified at this stage. Thus, there are necessary graphic sketches and personality traits of each one. If these features do not change from one scene to another, previous definitions can be reused. Consider that it is also possible that a character changes his/her clothes or mood from one scene to another, or even within the same scene when the scenario changes.

Similarly, all interactive objects present in the scenarios (and associated with the scene) shall be designed. In addition to a graphical sketch, each object must be described by defining all its properties and its possible states. Additionally, if it can be stored in the player's inventory, this will be indicated.

Before starting the design stages of actions and dialogues that will take place on the scene, a design stage of educational challenges is addressed. At this stage, the way in which the educational competences will be endorsed in the scene must be decided. These competences are labeled on the scene during the stage of scene design. In the following stages, these educational challenges materialize in the form of actions and dialogues.

During the design of the actions that a player can perform in a scene, a diagram of actions has to be developed. The actions represent the lowest level of abstraction in game activity. In many cases, these actions involve the use of interactive objects present in the scenario or previously stored in the avatar's inventory. Dialoguing with a character in the scene is a special type of action that is also included in the diagram of actions. Associated with these actions, the educational challenges are annotated on this diagram. Challenges have three possible states: initial, working, or under assessment. They will refine the educational challenges described in the previous stage (in a supplementary table). Following the example of the act of Rome, the diagram of actions corresponding to the scene of repairing the chariot has a total of fifteen actions and four educational challenges; For example, the action *get fodder* associates the educational challenge with code *004*, where the player infers the use of the pitchfork to collect fodder.

Finally, the design of the dialogues has to be addressed. At this stage, dialogues between different characters in the scene, indicating all possible flows of interventions, will be written. Also, it is possible to label the related educational challenges at specific points of the dialogues. As a result, several diagrams of dialogues will be obtained. The corresponding long texts will be included in a supplementary table. Following the example of the *repair chariot* scene, a dialogue takes place between the old man and the player. This dialogue has a maximum of eight sentences depending on the conversation path; in addition, this dialogue includes an educational challenge (with code *001*). In this case, the old man describes what to do to repair the chariot, so the player needs to use reading comprehension.

As Fig. 3 shows, additionally there are two transversal stages: design of the game play and design of the adaptation. The game play requires defining the game dynamics and rules for the whole game, while the adaptation implies identifying the parts of the video game susceptible to adaptation, and to specify the adaptation rules for their automatic execution during the game (these two stages are outside of the scope of this paper). All the artifacts will be refined iteratively, especially the set of design diagrams. For its representation, the authors propose a set of UML notations [49] but the diagrams could be modeled with other approaches such as the adaptation of UML proposed by Cooper and Longstreet [44], so that the methodology is not dependent on the notation used to represent the generated artifacts.

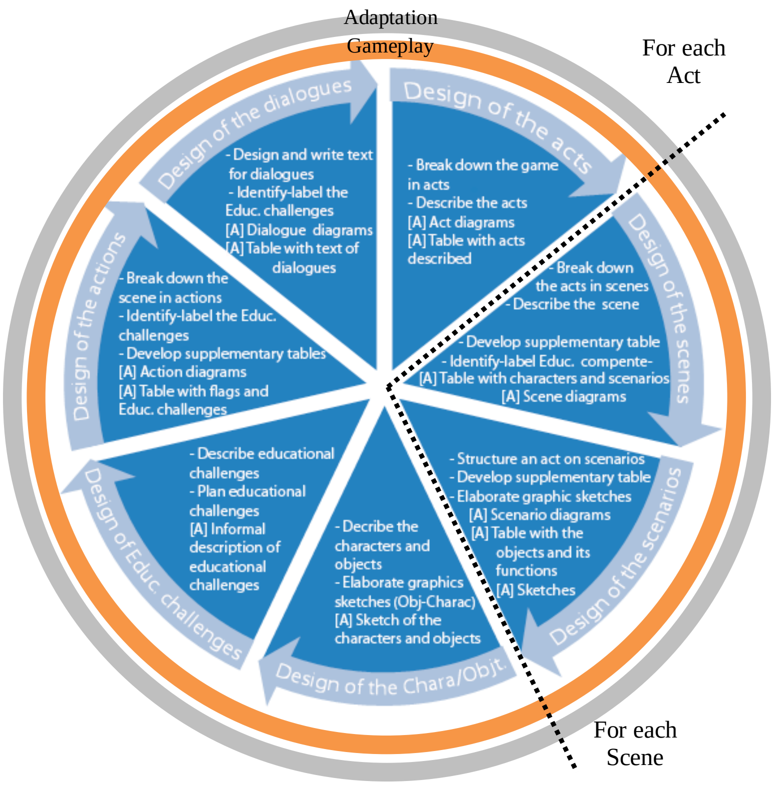

Fig. 3. Modeling tasks and artifacts generated. (Note: [A] indicates artifact.)

C. Roles

As it happens in some agile methodologies like Scrum [32] or SUM [31] (commented in Section 2), it is necessary to define a set of roles to assign the different tasks. The authors define the following roles:

- Project manager (PM). Although there is not a modeling task assigned to this role, the project manager could intervene in facilitating meetings between different roles or solving potential conflicts. PM is leader of project and is ultimately responsible.
- Computer Analyst (CA).This role is responsible of all the tasks which imply creating diagrams (breakdown of the game in acts or the act in scenes) or to develop supplementary tables.
- Designer (D). This person is responsible for all graphic design of the project (characters, scenarios, and objects).
- Client (C). This role is taken into account in many important tasks such as the elaboration of graphics, sketches of characters, scenarios, or objects. In this way the final satisfaction of client will increase.
- Writer (W). This person is responsible for tasks involving narrative (describe of acts, scenes, objects, or writer of the text for dialogues).
- Educator (E).This role is assigned all the tasks related to educational challenges. For example: identify and label educational challenges. It is fundamental that the educator collaborates in some tasks such as: *breakdown of the game in acts* or *breakdown of the act in scenes* among others, since this will facilitate the design and balance of educational challenges in the different acts or scenes.

Table 1 shows a summary of the tasks of modeling, together with the associated roles and the related key concepts. The Stage column is a code for indentifying each stage (Design of the acts→DACTS, Design of the scenes→DSCENE…).

TABLE I. RELATIONS BETWEEN MODELING TASKS, ROLES (PROJECT MANAGER (PM), COMPUTER ANALYST (CA), CLIENT (C), DESIGNER (D), WRITER (W) AND EDUCATOR (E), AND KEY CONCEPTS.

Stage	Modeling tasks	Roles	Key concepts
DACTS	Break down the game in acts	CA, E	Acts
DACTS	Describe the acts	C, W	Acts
DSCENE	Break down the act in scenes	CA, E	Acts, Scenes
DSCENE	Describe of the scenes	C, W	Scenes
DSCENE	Develop supplementary table	CA	Scenes, Characters, Scenarios
DSCENE	Identify-label Educ. competences	E, CA	Educ. Competences, Scenes
DSCNAR	Structure an act in scenarios	CA, E	Scenarios, Acts
DSCNAR	Develop supplementary table	CA	Scenarios, Objects, Scene
DSCNAR	Elaborate graphics sketches (Scenarios)	D, C	Scenarios, Objects
DCH-OB	Description of the characters	D, E, C	Characters
DCH-OB	Description of the objects	D, E, C, W	Objects
DCH-OB	Elaborate graphics sketches (Characters)	D, E, C	Characters
DCH-OB	Elaborate graphics sketches (Objects)	D, E, C	Objects
DACTIO	Plan the educational challenges	E	Educ. Challenges
DACTIO	Describe the educational challenges	E	Educ. Challenges, Objects, Characters
DDIALO	Break down the scene in actions	CA, E	Actions, Scenes
DDIALO	Identify-label Educ. challenges	E, CA	Educ. Challenges, Actions
DDIALO	Develop supplementary table	E, CA	Actions, Educ. Challenges
DEDUC	Write the text for dialogues	W, E	Dialogues
DEDUC	Design the dialogues	E, CA	Dialogues
DEDUC	Identify-label Educ. challenges	E, CA	Educ. Challenges-Dialogues
DEDUC	Develop supplementary table	E, CA	Dialogues

V. PHASES OF PRODUCTION, TEST AND POST-PRODUCTION

As discussed above, this work focuses on the design phase of the educational video game. However, this section will describe the phases of production, test, and post-production in general terms.

In the production phase, the technical or development team must program and model (2D/3D) the different artifacts (diagrams, supplementary tables, documents or sketches) of the design phase. This phase, as expected, is common in most life cycles for games defined in scientific literature, although not always with the same approach or with the same tasks associated. In this work, the proposal of the authors establishes similar production tasks to those by Chandler [50], Ramadan and Widyani [22] or Blitz Games Studios [25] with some adaptations due to differences in the design phase that precedes it, and the serious nature of the video game. The authors therefore define the following tasks:

- Choice of game engine. For example, in *Uranus* the game engine is Unity3D [51].
- Graphic design of the sketches of characters, objects and scenarios.
- Interpret all the artifacts of the design phase to implement the code to represent the movement of the characters, as well as all actions.
- Design of the sound effects and insertion in the dynamics of the game.
- Depending on the size and type of game, generate prototypes for each act, for each scene, or for each set of actions.
- Possibility of consulting with the pedagogical team regarding the evaluation or implementation of the educational challenges.

As with the production phase, the test phase is present in any life cycle, not just in video games, but in any software product. Of all proposals analyzed and due to its incremental character and its division between alpha and beta tests, the test phase of Ramadan and Widyani [22] has been used as a reference (with some adaptations).

Each prototype has a specific set of tests, and although sometimes they can be reused, alpha tests are performed to evaluate functionality, accessibility, and to detect possible bugs, documenting the serious errors for later analysis. As an adaptation, in alpha tests educators must analyze the different educational challenges. Once the prototype has passed the alpha tests, this is evaluated by members who are not part of the technical team. There are two non-exclusive modalities, open beta and closed bet. Open allows any individual to participate, while closed beta restricts participation to personnel belonging to the project. On the other hand, the beta tests have three levels respective to the two by Ramadan and Widyani [22], (1) tests on the concrete and detailed functionalities, (2) refinement tests, where the testers have total freedom; in other words, they discover possible errors or inconsistencies basically by playing. (3) Tests on educational challenges, but also of the game context and the balance between the ludic and educational aspects. As part of the beta tests the educators could do a real experiment with a small group of students. Again, any error or suggestion about the game is documented. All this process is repeated for each prototype until completing the game. Finally, as a satisfactory result of beta tests, the released version of the game is obtained.

Finally, in the post-production phase, (other authors call it release [22, 23], live [24], closure [35] or master [25]), this proposal assumes the more usual denomination, used by authors like Pereira [52], Chandler [50], Sykes and Federoff [53] or Arnab [29]: post-production. In this last phase there are not many tasks that need to be done, and this leads to this phase being completely ignored in many cases, which is a big mistake, since it can become just as important as the rest of phases (although the number of hours of effort is significantly lower than the rest of the phases of any game development life cycle). Some authors like Chandler [50] emphasize this same aspect about the post-production phase: “many times this step is forgotten or ignored, which is unfortunate”. This phase includes two important tasks, as described by Chandler [50]:

- Learning from experience: learning from the experience of developing a game is the best way to optimize all these complex processes, keeping in mind future developments.
- Archive plan: all code, sound, graphic, or documentation files must be properly archived and categorized, in order to be able to handle possible extensions, such as other versions of the game or adapt the game play to a new hardware device.

VI. CONCLUSIONS AND FUTURE WORK

A methodology to design educational video games, which is especially suitable for games where the story is a fundamental key point (e.g. graphic adventures) has been described within this work. This particular methodology proposes a five-stage life cycle: startup, design, production, tests, and post-production, although in the paper itself the design stage is most emphasized. The key elements during the design of an educational video game (with important narrative content) have been made explicit in order to address every necessary modeling task. Only in this way is it possible to improve the educational aspects of the game, as well as the quality of the final product. Precisely, the crucial objective of the proposal is to facilitate the balance between play and learning. With this aim, the design phase is broken down into various stages where an iterative and incremental series of modeling tasks produce a set of artifacts, such as: diagrams and other descriptive documents relating to the acts, scenes, scenarios, actions, dialogues, characters, and interactive objects that structure the game (using a metaphor with the world of theater). The generated artifacts can use any representation language that allows an adequate communication with the pedagogical team, and other human experts playing a role in the game design process, although the authors suggest an adaptation of UML. Last, and not least, a series of roles have been defined in order to assign the responsibilities of the different modeling tasks.

In future works, the design of the adaptation, sound, and game play will be described in depth. In addition, aspects such as collaboration between players to achieve global challenges could be analyzed with the intention of including them in the methodology’s design phase. At the same time, it is also essential to validate the proposal with the stakeholders (development team, pedagogues, designers, etc.) to confirm the proposed methodological process, which is being performed during the design of the game *Uranus*: *The invasion of the thieves of planets*.

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REFERENCES

[1] S.C. Bratton, D. Ray, T. Rhine and L. Jones,“The Efficacy of Play Therapy With Children: A Meta-Analytic Review of Treatment Outcomes”, Professional Psychology, Research and Practice,vol. 36(4), pp.376–390, 2005.

[2] J. Huizinga, Homo Ludens, Alianza/Emecé, Madrid, 1995.

[3] K. Zuse, Patentanmeldung Z-2391, German Patent Office, 1941.

[4] J.T.T. Goldsmith, M.E. Ray, Cathode-ray tube amusement device. US Patent 2,455,992, 14 Dec 1948.

[5] R. Rosas, M. Nussbaum, P. Cumsille, V. Marionov, M. Correa, P. Flores et al.,“Beyond nintendo: design and assessment of educational video games for first and second grade students”. Computers & Education,vol. 40(1), pp. 71–94, 2003.

[6] Y.A. Carretero, “Desarmando el poder antisocial de los videojuegos”, Revista electrónica interuniversitaria de formación del profesorado, vol. 14(2), pp. 97–103, 2002.

[7] M. Griffiths, “The educational benefits of videogames”, Education & Health,vol. 20, pp. 47–51, 2002.

[8] C.K. Olson, L.A. Kutner and D.E. Warner, “The role of violent video game content in adolescent development boys’ perspectives, Journal of Adolescent Research, vol. 23(1), pp. 55-75, 2008.

[9] J.F. Knight, S. Carley, B. Tregunna, S. Jarvis, R. Smithies, de Freitas et al.,“Serious gaming technology in major incident triage training: a pragmatic controlled trial”, Resuscitation,vol. 81(9), pp. 1175-1179, 2010.

[10] F. Fernández-Aranda, S. Jiménez-Murcia, J.J. Santamaría, K. Gunnard, A. Soto, E. Kalapanidas et al.,“Video games as a complementary therapy tool in mental disorders: PlayMancer, a European multicentre study”, Mental Health, vol. 21(4), pp. 364-374, 2012.

[11] M. Zyda, “From visual simulation to virtual reality to games”, Computer, vol. 38(9), pp. 25-32, 2005.

[12] G. Saposnik, R. Teasell, M. Mamdani, J. Hall, W. Mcllroy,D. Cheung et al.,“Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation”, Stroke, vol. 41(7), pp. 1477-1484, 2010.

[13] M. Muratet, P. Torguet, F. Viallet, J.P. Jessel, “Experimental feedback on Prog&Play: a serious game for programming practice”, Computer Graphics Forum, vol. 30(1), pp. 61-73, 2011.

[14] V. Guillén-Nieto and M. Aleson-Carbonell,“Serious games and learning effectiveness: The case of It’s a Deal!”, Computers & Education, vol. 58(1), pp. 435-448, 2012.

[15] V. Janarthanan,“Serious video games: Games for education and health”, in: Information Technology: New Generations (ITNG) (Eds.) Ninth International Conference, IEEE, pp. 875, 2012.

[16] R.E. Clark,“Learning from serious games? arguments, evidence, and research suggestions”, Educational Technology, vol. 47(3), pp. 56–59, 2007.

[17] J.B. Hauge, R. Berta, G. Fiucci, B.F. Manjón, C. Padrón-Napoles, W. Westra et al.,“Implications of learning analytics for serious game design”, in: IEEE 14th International Conference on Advanced Learning Technologies, IEEE, pp. 230, 2014.

[18] K. Salen and E. Zimmerman, Rules of play: Game design fundamentals, MIT press, 2004.

[19] R. Koster, Theory of fun for game design, O’Reilly Media, Inc., 2013.

[20] J. Schell, The Art of Game Design: A book of lenses, CRC Press, 2014.

[21] T. Fullerton, Game design workshop: a playcentric approach to creating innovative games, CRC press, 2014.

[22] R. Ramadan and Y. Widyani, “Game development life cycle guidelines”, in: Advanced Computer Science and Information Systems (ICACSIS), 2013 International Conference, IEEE, pp. 95-100, 2013.

[23] J. McGrath, “The game development lifecycle: A theory for the extension of the agile project methodology”, Available via online. http://blog.dopplerinteractive.com/post/112172271166/the-game-development-lifecycle-a-theory-for-the[Accessed 05/06/17], 2014.

[24] A. Hendrick, “Project Management for Game Development”, Available via online. https://mmotidbits.com/2009/06/15/project-management-for-game-development/[Accessed 05/06/17], 2009.

[25] Blitz Games Studios, “Game Development: Project lifecycle”, Available via online. http://www.blitzgamesstudios.com/blitz_academy/game_dev/project_lifecycle [Accessed 13/06/17], 2013.

[26] A. Hirumi and C. Stapleton, “Applying pedagogy during game development to enhance game-based learning”, in Games: Purpose and potential in education, pp. 127-162, Springer US, 2009.

[27] T. Bjørner and C.B.S. Hansen, “Designing an Educational Game: Design Principles from a Holistic Perspective”, International Journal of Learning, vol. 17(10), pp. 279-290, 2010.

[28] B. Roungas and F. Dalpiaz, “A Model-Driven Framework for Educational Game Design”, in: De Gloria A., Veltkamp R. (Eds.) Games and Learning Alliance, GALA 2015, Lecture Notes in Computer Science, vol. 9599, Springer, Cham, 2016.

[29] S. Arnab, T. Lim, M.B. Carvalho, F. Bellotti, S. Freitas, S. Louchart, ... & A. De Gloria, “Mapping learning and game mechanics for serious games analysis”. British Journal of Educational Technology, vol. 46(2), pp. 391-411, 2015.

[30] S. Arnab, S. Clarke,“Towards a trans-disciplinary methodology for a game-based intervention development process”, British Journal of Educational Technology, vol. 48(2), pp. 279–312, 2016.

[31] N. Padilla Zea, N. Medina-Medina, F. Gutiérrez-Vela and P. Paderewski,“A model-Based approach to designing educational multiplayer video games”, Technology-Enhanced Systems and Tools for Collaborative Learning Scaffolding, Springer, pp. 167-191, 2011.

[32] A. Rollings and E. Adams, Andrew Rollings and Ernest Adams on game design. New Riders, 2003.

[33] I. Horrocks, Constructing the user interface with statecharts. Addison-Wesley Longman Publishing Co., Inc., 1999.

[34] C. Crawford, The Art of Interactive Design: a euphonious and illuminating guide to building successful software. No Starch Press, 2002.

[35] N. Acerenza, A. Coppes, G. Mesa, A. Viera, E. Fernández-Albano, T. Laurenzo et al.,“Una Metodología para Desarrollo de Videojuegos”, in: Anales 38º JAIIO Simposio Argentino de Ing. de Software (ASSE 2009), pp. 171, 2009.

[36] K. Schwaber, J. Sutherland, The scrum guide. Scrum Alliance, 2011.

[37] Software and Systems Process Engineering Metamodel specification (SPEM). Version 2.0. http://www.omg.org/spec/SPEM/2.0 [Accessed 14/11/16].

[38] I. Marfisi-Schottman, A. Sghaier, S. George, F. Tarpin-Bernard and P. Prévôt, “Towards industrialized conception and production of serious games”, in: Proceeding of The International Conference on Technology and Education, Paris, 2009.

[39] R.J. Nadolski, H.G. Hummel, H.J. Van Den Brink et al., “EMERGO: A methodology and toolkit for developing serious games in higher education”, Simulation & Gaming, vol. 39(3), pp. 338-352, 2008.

[40] E.M. Whyte,J.M. Smyth andK.S. Scherf, “Designing serious game interventions for individuals with autism”, Autism and developmental disorders vol. 45(12), pp. 3820–3831, 2015.

[41] GEDES, Available via online. https://lsi.ugr.es/lsi/gedes [Accessed 14/06/17].

[42] R.P. De Lope and N. Medina Medina, “A Comprehensive Taxonomy for Serious Games”, Journal of Educational Computing Research, vol. 0(0), pp. 1-44, 2016.

[43] VirtualWare group, Available via online.http://virtualwaregroup.com/es [Accessed 25/10/17].

[44] Greyman SL, Available via online.http://greymanstudios.com/es/ [Accessed 15/06/17].

[45] K.M. Cooper and C.S. Longstreet,“Towards model-driven game engineering for serious educational games: Tailored use cases for game requirements”, in: Computer Games (CGAMES), 2012 17th International Conference, IEEE, pp. 208, 2012.

[46] M. Belinkie,“The video game plot scale”, Available via online. https://www.overthinkingit.com/2011/08/30/video-game-plot-scale/[Accessed 02/01/17], 2011.

[47] R.P. De Lope, N. Medina-Medina, J. Molina López,“Interaction in Serious Games”, in: Interaction ’16 Proceedings of the XVII International Conference on Human Computer Interaction. ACM, Salamanca, article nº 4, 2016.

[48] Government of Spain. Ley orgánica 8/2013, de 9 de diciembre, para la mejora de la calidad educativa.

[49] R.P. De Lope andN. Medina-Medina,“Using UML to Model Educational Games”, in: Games and Virtual Worlds for Serious Applications (VS-Games), 8th International Conference, IEEE, pp. 1-4, 2016.

[50] H.M. Chandler, The game production handbook. Jones & Bartlett Publishers, 2009.

[51] Unity, Available via online. https://unity3d.com/es [Accessed 12/06/17]

[52] A.M.M. Pereira, “El proceso productivo del videojuego: fases de producción/The production process of the game: production phases”, Historia y Comunicación Social, vol. 19, 791, 2014.

[53] J. Sykes, and M. Federoff, “Player-centred game design”, In CHI'06 extended abstracts on Human factors in computing systems, pp. 1731-1734, ACM, 2006.