# Design methodology for educational games based on interactive screenplays

Rafael Prieto de Lope · Nuria Medina-Medina · Patricia Paderewski · F.L. Gutiérrez-Vela

Centro de Investigación en Tecnologías de la Información y la Comunicación, Universidad de Granada (CITIC-UGR). C/ Periodista Rafael Gómez Montero 2, 18014, Granada, Spain.
rapride@correo.ugr.es nmedina@ugr.es patricia@ugr.es fgutierr@ugr.es

**Abstract.** A number of studies have been published on the benefits offered by educational video games for student development and there has been a constant increase in the use of serious games for this purpose. Very few methodological proposals for educational video game development, however, have been published in scientific literature 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 interactive screenplays. 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.

**Keywords:** Serious games, educational games, development methodology

## 1 Introduction

All games whether commercial or non-commercial have a number of common features such as high interactivity, fun, rules that the player must follow and in many cases a competitive element. Serious games [24][3], however, are not only aimed at providing entertainment or competiveness but also at exploiting these in order to improve training in areas such as education, public policy, health or communication strategies.

In recent years, there has been a boom in the number of serious games, and since 2007 there has been a considerable increase in the scientific production in this field. 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 [23]. Another relevant fact is shown by Vargas [20] 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. It is possible that educational video games (also called educational games in this paper) can provide that missing motivation, thereby making them an excellent teaching tool

for teachers. Correspondingly, a number of studies have identified certain advantages of using video games in education [5] [16] [18] in that 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
- improve cognitive skills (e.g. strategic planning, multiple learning styles, etc.)

Our aim in this article is to highlight the shortage that still exists of specific methodologies for designing educational games that must be conceived by non-technical personnel (including educators, writers and artists) to be used by software developers. The article is organized as follows. Section 2 outlines the current state of methodologies for designing the video games and educational games discussed in Section 3. Section 4 describes our approach in an attempt to reduce the previously identified disadvantages and briefly describes a video game currently being developed. Finally, Section 5 presents our conclusions and the framework for the application of the proposed methodology (that of the development of an educational game to teach comprehensive reading to upper primary school children [11]).

## 2 State of scientific literature on game development methodology

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. In addition, certain authors have even defined a preliminary phase [19]. Our interest, however, lies in the development of game-specific methodologies and with this in mind these methodologies and processes are outlined below.

**5M methodology for games**

The 5M classification is often used in the engineering industry and can be applied to video game development as follows [12]:

- 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

**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 educational objectives and play challenges that the game activities share with the educational tasks being implicitly undertaken.

**Methodology based on Westera levels**

This approach combines three different levels [22] 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

**SUM methodology**

SUM is an agile methodology for game development that adapts the Scrum structure and roles [1]. 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.

**Ontological methodology**

In his work, Llansó [8] 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.

## 3 Discussion about existing proposals

Although game development in general and the design of educational video games in particular are complex processes that are far removed from conventional software development, very little has so far been published on the design or development of serious or educational games from a specific perspective. Among the work that stands out in this field is the ontological methodology. This emphasizes the particular characteristics of working with a multidisciplinary team, which is essential for game development, and offers a complete guide to solving this problem. There are, however, certain drawbacks that are not restricted to serious games (and possibly this type of video game should be disregarded) and the main focus is on facilitating communication between the different team members while ignoring other difficulties which are inherent to the design itself. In addition, the ontological syntax may not be intuitive to non-technical staff.

The collaborative learning methodology presented in [14] considers collaboration to be an enriching part of the learning process. By employing very formal models, however, it lacks graphical notations that are easy for the multidisciplinary team members to understand. Since the SUM methodology is directed towards video games in general and is defined for small projects, it is not suitable for the purpose of this study (although it might be considered supplementary). Similarly, the 5M methodology proposes an interesting production process for educational games, but is unsuitable for software engineering. The following common shortcomings have also been identified:

- There is no sufficiently detailed process to explain the series of steps to be followed when constructing the interactive story around which the game will be executed.
- There is a lack of mechanisms to enable collaboration, except in the methodology [14] which defines the rules of collaboration or cooperation between two or more players in order to achieve goals, challenges and achievements.

- There is no clear or definite correspondence between education and fun, except in the proposal in [14] where the formalization of this interrelation is fundamental to the game balance. In this article, however, we only explore the conceptual level of educational and recreational purposes and do not define how educational challenges are included within the game narrative.
- No graphical notations are used to specify the game: graphical notations are only used in the work by Llansó [8] and then as a supplement. Graphical notations are useful for non-technical staff, designers and developers alike.

## 4 A new methodology based on interactive screenplays

The methodology proposed in this paper focuses on educational games with narrative and begins with the narrative screenplay of the game organized into chapters and scenes. The various other game elements are then progressively added to this script (e.g. scenarios, characters, fun and educational challenges, etc.). The use of narrative as the core helps writers, educators and artists construct the adventure and dynamics of the game, and is supported and complemented throughout the process by the designers. A series of graphical notations can then be generated from the interactive script such as diagrams showing the challenges, objects and scenarios. Not only do these diagrams provide an abstract view of the game but they also facilitate video game implementation and can be directly interpreted by the developers who were not involved in the design.

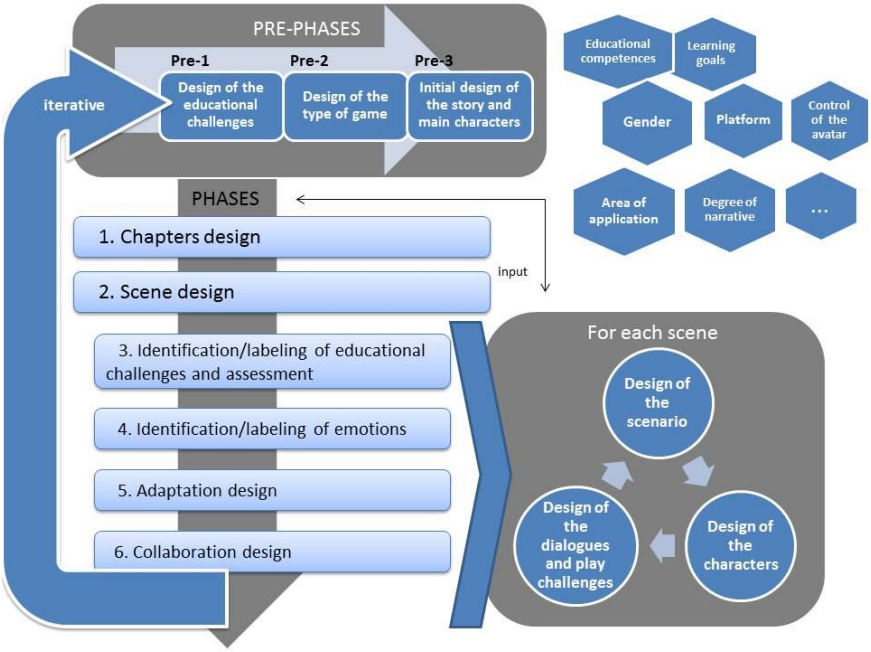


**Fig.**1. Methodology based on interactive screenplay

More specifically, the methodology comprises a series of ordered, iterative steps (Figure 1) that begins with three preliminary phases.

**Pre1. Design of the educational challenges: basic competences and educational objectives**

In this first phase, the team of teachers and educators (which could also include parents and guardians) determines the competences and specific educational objectives that the game will address. In the first step, the team defines the competences. A competence is considered to be more than knowledge and skills and involves the ability to meet complex demands, supporting and mobilizing psychosocial resources (including skills and attitudes) in a particular context [4]. For example, the following eight basic skills [9] [10] are defined for the Spanish education system:

1. linguistic communicative competence
2. mathematical competence
3. knowledge of and interaction with the physical world
4. data processing and digital competence
5. learning to learn
6. social and civic competence
7. autonomy and personal initiative
8. cultural and artistic competence

Depending on the game's pedagogical framework, certain skills will of course be included. In the second step, educational goals are established whereby the objectives to be achieved during the development of an educational cycle or specific subject are defined, and these will be integrated either directly or indirectly into subsequent achievement assessment as the game is used. In this pre-phase, the teaching team could use curricular models with which they are familiar.

**Pre2. Design of the type of game**

Before designing the story and challenges of the game it is necessary to determine a series of game characteristics that may affect subsequent design decisions. These features include gender, avatar control, platform, future users, narrative level, area of application and interactivity. For example, the classification of [7] could be used to determine the video game genre (e.g. action, adventure, fight, logic, simulation, sport, strategy, etc.).

The platform used could be a PC, console or smartphone/tablet and in order to identify future users the age recommended in [15] could be used or more specifically, the group at which the game is aimed (e.g. primary pupils). Depending on the narrative level to be included in the video game and based on [2] but with a reduction in the number of categorization criteria from ten to six, the following types could be established: no narrative, elementary narrative, basic narrative, full narrative, complex narrative and "narrative is everything" (from the lowest to highest weight of the narrative in the game). From the perspective of how players control their avatars, it is necessary to establish whether there is third or first person avatar control (for any avatar appearing on the scene) or if any avatar may represent the player (for example, sever-

al characters are controlled as in Sim or none as in Tetris). Finally, interaction establishes how the player or players interact with the game, whether active (by interacting with their own body) or standard (by interacting using special or common peripherals). It is also possible at this stage to decide whether interaction is point & click or touch (although this will obviously depend on the platform chosen). Esthetic aspects and choice of 2D or 3D could also be specified in this pre-phase to be considered during the character design phase.

**Pre3. Initial design of the story and main characters**

Generally speaking, in order to fully define the game's story, various iterations are required and the number of these is likely to be proportional to the narrative level. When a complex, full or everything narrative is chosen, it is easy to lose the overall view of the adventure and the associated dynamics. In order to reduce this risk, an initial, abstract story design should be drawn up. Some or all of the main characters that will appear in the future game are also chosen. This design could be enhanced with graphical sketches.

With these three pre-phases, this initial conception enables the design team to tackle each of the phases listed below.

**1. Chapter design**

In the methodology proposed, a chapter is defined as the item of the highest level that is used to organize the story and facilitate content integration. Each game should comprise at least one chapter, although there are usually several. The transition and order of the chapters can be established using a chapter flowchart. In order to define each chapter, it is necessary to provide an identifier, an abbreviated name and the plot of the chapter's overall adventure. The Hero's Journey [21] is one example of how the story line can be organized into chapters and these include *Ordinary World*, *Call to Adventure*, *Refusal of the Call*, *Meeting with the Mentor*, *Crossing the First Threshold*, *Tests, Allies and Enemies*, *Approach to the Inmost Cave*, *The Ordeal*, *Reward*, *The Road Back*, *Resurrection* and *Return with the Elixir*.

While not compulsory, it is possible to specify the different educational objectives of each chapter in order to ensure early on that the educational component is balanced between chapters.

**2. Scene design**

Each chapter is split into scenes which comprise the chapter story line in the same way as the scenes of a play or film. The number and order of scenes in a chapter can be specified using a scene flowchart. Since the flow is not normally unique, the design team can define transitions depending on a player's future decisions and actions, which would mean that certain scenes are optional (i.e. the player does not have to live them all).

Once each scene in the chapter has been described with its name and brief summary, the items listed below are specified.

*Design of the scenario*

In this phase, the scenario of the scene is described and identified with an ID. The scenario is the place where the actions and dialogues occur in a scene. The scenario definition includes both a static and a dynamic part. While the static part defines the environment (e.g. room, lake, etc.) and the objects to be found there (e.g. table, wall chart, weapon, etc.), the dynamic part defines object interactivity (e.g. inventoried or not, mobile or not, associated powers, etc.) in the scene. Some objects can therefore have certain associated interactions (e.g. take the object, change some of its attributes, move it, etc.) in one scene but not another. For this reason, the scenario is included in the scene description. When one scenario is statically and dynamically identical to the scenario of another scene, it is therefore not redefined but the ID is used directly.

*Design of the characters*

In the scenario and during the scene, one or more characters will appear, some of which will have been briefly described in the third pre-phase. The first time characters appear, it is necessary to describe in detail their characters (and these can subsequently be expanded upon in successive iterations), appearance and personality. Initially, words can be used to describe their physical appearance but in successive iterations, graphical sketches can be used. Whenever a character is involved in future action, there is no need to describe them again, except if some of their attributes have changed (for example, they are wearing different clothes or have become bad-tempered because of something that happened).

*Design of the dialogues and play challenges*

During the scene, the characters perform various actions in order to overcome the game's play challenges and they can also talk to each other and hold dialogues. Again, a flowchart can be used to describe the actions and/or dialogues that comprise the scene. There is the added difficulty that the order is not usually fixed and there will be some flexibility (or free will) in the scene so that the players can choose their own game paths.

Each action or dialogue must then be defined. In a first iteration of the proposed methodology, a dialogue or challenge can be described in a couple of words but at a later stage, it is necessary to outline the sequence of steps needed to complete each action and the exchange of phrases in the dialogue using a series of diagrams. For dialogues, it is possible to adapt traditional film scripts, indicating the character who speaks and their mood (or other applicable attribute) in each intervention.

Once again, when the avatar participates in a dialogue it is important to note that in order to increase the fun and complexity; the dialogue will not be closed but will depend on the answers chosen by the player. These decisions should be specified in the dialogue flowchart. Because of the possible dialogue complexity, it is advisable to first define the successful dialogue (the key to overcoming the challenges of the scene) and gradually add new alternatives. Play challenges (actions) can be part of a larger play challenge and can also be recorded as necessary for the future score in the game. At the end of this phase, therefore, the game mechanics and score should be clear.

*3. Identification / labeling of educational challenges and assessment*

Associated with the play challenges are the education objectives being pursued and these are hidden in certain parts of the dialogues. In this case, it is possible to specify that a particular point of the dialogue poses an educational challenge or offer some information needed to solve it. It is also necessary to indicate when a response in a dialogue, a step or a complete play challenge (in an action) is the solution to an educational challenge. Whenever an educational goal is achieved, the corresponding evaluation rule should be defined. The evaluation rule may have associated conditions for its application and will use the values collected in different parts of the scene (or even in other scenes) where the player has been working on the educational task.

Finally, it should be noted that the educational component can be divided not only among the play actions and dialogues but also the scenario objects (for example, a letter that provides specific knowledge to solve an educational challenge or an interaction with an object that means that the educational goal has been reached). This also could be recorded in this phase.

*4. Identification/labeling of emotions*

One aspect that should not be overlooked when designing a scene is the identification of emotions that we wish the player to display. For this, the emotions established in [17] will be classified in order to design the player's experience, marking the parts of the dialogue or the steps of an action that aim to evoke a particular emotional reaction. It is apparent from the study in [6] that this is a complex process and the viewer's responses through their emotions are analyzed in depth as the viewer watches a video, defining the two axes of *valence* and *excitement* to represent these emotions.

*5. Adaptation design*

In this phase, it is necessary to determine whether the game is capable of adapting to the player's capabilities and characteristics, the game device or the environment. We therefore need to define what attributes can be customizable in the game (e.g. educational challenges, interaction mode, narrative, evaluation rules, etc.), based on the properties (the player's knowledge, tastes and preferences, device resolution, physical context, etc.), how adjustments should be made (adaptation techniques to modify difficulty, change a character's appearance, etc.) and when (time when the adjustment is made and how the player controls this). Although some methodologies do exist that create product lines which can be adapted to different groups [13], we have created a single product that can be adapted by adjusting certain features to suit the requirements of each child in the same group or school year.

*6. Collaboration design*

Following the collaborative proposal in [14], it is necessary to mark the actions (play challenges) or steps within the actions that must or can (as determined) be performed in groups.

**Use Case: Designing a videogame for comprehensive reading**

This methodology has been conceived from our experience of designing an educational game [11] to practice comprehensive reading and which is still being developed. The game is an adventure with 2D graphics and point & click interaction. The narrative tells the story of a boy/girl (adjustable avatar) on which the future of planet Earth depends. For this, the avatar must travel back in time and find certain characters (e.g. Cleopatra) who will give him/her historically important items so that the player to meet the challenges required). The avatar must give these treasures to a series of evil aliens who are aiming to clone or destroy Earth.

We use graphical notations to ease communication between members of our multidisciplinary team. The following figure shows a simplified version of the scene diagram for a chapter where the avatar must accomplish a goal.

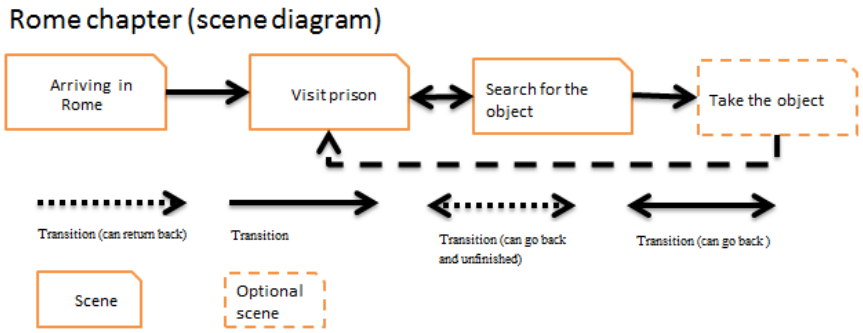


**Fig.**2. Scene diagram example

As the example illustrates, the Rome chapter comprises four scenes, one of which is optional (the video game can proceed if this scene is omitted). It is also possible to observe three types of transitions: standard transition, go back transition, and in the final optional scene you can see how it is possible to go to the visit prison scene without having completed a scene.

## 5 Conclusion and future work

Despite the great impact of video games on contemporary society and their proven value for supporting and enriching the learning process of schoolchildren of all ages, there are currently few specific methodologies for developing educational video games and the ones that do exist display certain shortcomings as discussed previously. This paper, therefore, presents a new proposal which is based on an interactive screenplay that integrates all transverse game aspects.

Our methodology proposes a bottom-up strategy since the overall game design (educational objectives, type of game, history and main characters) is created in the first three pre-phases, to be further refined at a later stage in the chapters and scenes. A bottom-up strategy is performed and each detail is defined in an interactive screen-

play with the engagement of transverse aspects such as characters, scenarios, dialogues, challenges, emotions, adaptation rules, collaboration possibilities, play score and evaluation of educational goals as the transverse aspects. The interesting thing is that from this low-level script it is possible to create a series of more abstract diagrams depicting overall challenges, competence assessment, transitions between scenarios, object interactions, character evolution, emotional experience progress, etc. These results will be used by developers and can previously be used by designers to analyze the balance and correctness of the design. It should be mentioned that designing emotions, adaptation and collaboration is optional as not all games have these.

There are three main lines to our future work: firstly, to complete the graphical notations in order to produce the diagrams needed for each phase; secondly, to apply the methodology (including graphical notations) to finish designing our game so that it may be implemented by a company from the resources created; and thirdly, to incorporate the possibility of using a tool to assist with the creation of diagrams.

## Acknowledgments

This research is supported by the Ministry of Science and Innovation (Spain) as part of VIDECO project (TIN2011-26928) and the Andalusia Research Program under the project P11-TIC-7486 co-financed by FEDER (European Regional Development Fund - ERDF).

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