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Designing educational games through a conceptual model based on rules and scenarios

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Abstract The design of a successful educational game (EG) is a challenging task that requires a lot of knowledge and a variety of skills. EG designers not only have to deal with the inherent technical complexity of game design, but also have to be able to interweave learning activities in a way that is enjoyable and educationally effective at the same time. In order to make available the benefits of game based learning to a wider audience, it is necessary to provide means to alleviate the cost of envisioning new EG by providing tools that might contribute to make the design process easier and quicker. As a first step towards this goal, in this paper we introduce a conceptual model that organizes in a modular way and in different design perspectives the game features. In order to help EG designers, the features that are most often regarded in the literature as significant in producing engaging, fun and educational game experiences, have been included in the model through a set of design entities. Furthermore, the organization of the elements of the model facilitates reusing pieces of the EG designs to quickly produce variants of the same game which can be used to match different learning purposes. The opinions gathered from the educators and game designers that participated of an EG design workshop confirmed that the model can help multidisciplinary EG design teams. Moreover, the model successfully contributed to the process of designing a collection of EGs aimed at raising children´s awareness of emergencies and domestic risks, whose educational and ludic value was assessed in an experience conducted with students and educators at a primary school in Madrid.

Keywords Educational game · Game based learning · Game design · Modelling · Game design entities

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1 Introduction

Computer games can be considered a valuable educational resource due to their effectiveness in enhancing motivation and increasing student interest in the subject being taught [2, 8, 15, 31]. However, the extent and potential of Educational computer Games (EG), has been limited thus far due to several problems. EG designers not only have to deal with the difficulty of designing a game that engage the player, but also the difficulty of integrating in the game flow the required learning activities. It is necessary to carefully balance the educational and entertainment purposes of the game and to combine them in a subtle, indiscernible way [9, 24]. For this reason, it is necessary to face the design of EGs not only from a technical perspective but abstracting the features that will make it playable, enjoyable and educational at the same time. The complexity and sophistication of current computer games, in terms of graphical resources, interaction mechanisms, narratives and rules, might deter teachers and experts in the domain to be taught from creating their own EG or even from participating in their design due the lack of technical knowledge and jargon.

In order to alleviate these problems, some researchers have proposed models to facilitate the design of computer game supported learning processes and guarantee the quality of the final product, including [1, 16, 28, 29]. Despite the valuable contribution of these works in understanding educational game experiences, most of these design heuristics are difficult to use in practice, as in many cases they come in the form of high-level guidelines. Indeed, notations and models filling the gap between theoretical models and technical designs are precisely what are needed, both to facilitate the production of quality designs and to provide support in the reuse of their building blocks. Additionally, platforms such as eAdventure [30] or StoryTec [20] can simplify the development process but they are restricted to a very specific case of games, point and click adventures.

The work presented in this paper is part of a project that aims to provide means to reduce the high cost associated with the production of EGs. The EG development process includes three phases: a pre-production phase, in which the game concept is developed and the key game elements are prototyped; a production phase, whose result is a game implementation; and a post-production phase, concerned among other things with the product distribution. In this work we focus on the pre-production phase, during which the game concept design is carried out. In the case of the design of an EG, this phase usually requires the collaboration of different roles, such as the educators and domain experts, game designers and artists, etc. To support this design process we propose a conceptual EG model that organizes, in a modular way, game features often highlighted in the literature as being significant in producing engaging, fun and educational game experiences. Moreover, this model allows to these multidisciplinary teams to build EGs taking advantages of the reusability of its designs.

Each game feature has been specified through a series of design entities used to describe the EG. This approach provides a level of abstraction over the technical details, and serves as an intermediate layer between technical and highly conceptualized designs. The elements of the model are arranged from two different and independent perspectives, the rule perspective and the scenario perspective. An EG design description is then composed by the description of its rules and the description of the scenario in which the game will be played. The model supports the design process in two different ways. First, since designers are required to describe the games in terms of the elements of the model, they are force to pay attention to aspects and features both technical and educational that could otherwise have been overlooked. Second, since the designs follow the modular organization of the model, the reuse of design components is promoted and the adaptation of EG designs and production of variants is facilitated.

An experience conducted in collaboration with game designers and educators confirmed that the model can successfully support multidisciplinary EG design teams in their design tasks. Moreover, in order to evaluate the model's applicability it was used to design a series of EGs that are aimed at raising children's awareness of emergencies and domestic risks. In total 6 EG designs were created. 5 of them were obtained by reusing, adapting and extending pieces of an initial EG design. These designs were later implemented, and an evaluation with students and teachers from a primary school in Madrid confirmed that the EGs produced fulfil both their educational and entertainment purposes.

The rest of the paper is organized as follows. In Section 2 summarises the literature review on the subject that has guided the selection of the game features considered in the model. The model is introduced in Section 3 and its evaluations are described in Sections 4, 5 and 6. Finally, some conclusions and the current lines of work are presented.

2 Background

Several attempts have been made to analyse and understand the enjoyment and motivation derived from computer games. For instance, in the specific case of evaluating the playability of a game, Federoff [10] and Desurvire [7] proposed two different sets of heuristics. Whilst those from Federoff focus on aspects of the game such as its interface, mechanics and game play, those proposed Desurvire highlight the importance of the game play, story, mechanics and usability. Some of these features are also included in Prenksy's list of 12 characteristics [23] that make computer games engaging, which include fun, play, rules, goals, interactivity, adaptation, outcomes and feedback, win states, challenge, problem solving, interaction with computer and other players, representation and story. Other authors have taken as their starting point an analysis of the theory of flow proposed by Csikszentmihlayi, who described the flow as a state of deep involvement and engagement in the task being carried out, usually implying a high degree of absorption with its rewarding properties constituting an end in itself [6]. For instance, Sweetser model [29] proposes eight elements to be considered in a computer game to generate enjoyment: concentration, challenge, skills, control, clear goals, feedback, immersion, and social interaction. In the specific case of educational computer games, Kiili [16] combines flow theory, experiential learning theory and game design and singles out immediate feedback, clear goals and challenges adequate to the skill level of the player as key elements for a successful design. Other factors considered in Kiili's model include an engaging storyline and the use of appropriate graphics and sounds to optimize the cognitive load.

Another approach of analysing games is to focus on the factors that promote players' motivation for learning. Malone [19], for instance, proposed a framework for designing motivating learning experiences that puts the stress on intrinsically motivational factors such as challenge, curiosity, control and fantasy at the individual level, and cooperation, competition and recognition on an interpersonal level. Following these ideas, and after an exhaustive review of the literature on the subject, Garris [11] concluded that game characteristics can be described in terms of six broad dimensions or categories: fantasy, rules/goals, sensory stimuli, challenge, mystery, and control. In addition the same author proposed describing the game experience through an iterative game cycle of judgment-behaviour-feedback, which includes a specific phase of debriefing. Indeed the importance of including some sort of debriefing activity that allows the learner to apply what is learned in the game to the real world has been highlighted by several authors [5, 17, 18, 22]. In any case, as Fabricatore states in [9], focusing only on the motivational aspects of the game might result in EG which lack cohesion between the cognitive task and the game-play. In order to fully exploit the educational value of games,

this author proposes designing games in which the learning tasks are contextual to the game in the sense that they are perceived as a true element of the game-play.

Finally, and from the perspective of approaching the computer game as a software artefact, the MDA framework described in [13] distinguishes between the mechanics, the dynamics and the aesthetics of the game, and proposed a vocabulary for describing this latter component which included the terms sensation, fantasy, narrative, challenge, fellowship, discovery, expression and submission. In the case of educational computer games, Amory [1] proposed a theoretical model loosely based on the Object Oriented Programming paradigm, which establishes relations between the pedagogical dimensions of learning and the game design elements. The basis of the development will be the definition of a story line, which is linked to the learning objectives and which can be refined and split up into acts and scenes.

Table 1 summarizes the characteristics and game features most frequently regarded in all these research works as significant in a computer game experience. It is interesting to note that many of these features appear repeatedly, regardless of the perspective of the analysis, or the purpose of the model or heuristic. For example, most of the authors highlight the importance of proposing challenges that are appropriate to the player, to embed the game into a storyline or narrative, to provide interactivity and feedback mechanisms and to include some sort of socializing component. Unfortunately the guidance on how to capture these features in an EG design is often presented in a highly conceptualized, abstract way and so most of the heuristics proposed by Federoff [7], Desurvire [10] and Sweestser [29] come in the form of general guidelines, such as "create a great storyline" or "play should be fair". Similarly, Prensky [23] and Malone [19] propose lists of essential features which a game should have and recommendations that can be of great use to validate the quality of a design or to detect pitfalls in it. However, the examples of designs that exhibit these features are all given in narrative way, which do not outline the complex interplay between the various features of the game. The models of Hunicke [13], Garris [11], Kiili [16] go a bit further as they frame or associate some of these features to stages of the process of designing or playing a game. But again, they still offer little support on how to describe these features. In fact, as is the case in the previous pieces of work, the examples of design games are presented all in a completely descriptive way. This would make the adaptation or reuse of pieces of the designs difficult. Furthermore, it is arguable that the designer is given too much discretion to judge if the desired features or recommendations are really being implemented or not in the designs. In fact, only the model proposed by Amory in [1] specifies clear relationships between a set of game elements that can be used to describe a game. However, the use of Object Oriented Programming concepts in the model would make it difficult to be understood by people with a low technical profile, as might be the case for an educator. Furthermore, the main objective of the proposal is not to facilitate the reuse of design elements but to support writing stories for complex learning environments.

Taking the above considerations into account, we believe that an EG model which facilitates the description of EG designs that are easy to adapt and reuse is still missing. This type of model could provide the basis for developing methods and tools that will foster the reuse of pieces of EG designs, thereby accelerating the design process. The next section will develop these ideas and will propose a model for describing EG designs through a set of different types of design entities. The model defines a modular organization of the entities that establishes the way in which they inter-relate with each other, and seeks to facilitate the reuse and adaptation of pieces of game designs. The types of design entities the model considers have been selected taking into account the features most often regarded as significant in an EGs depicted in the Table 1.

Table 1 Summary of features of games highlighted in literature as significant during a game experience

	Game playability	Flow theory	Motivation	Software artefact
Goals/Challenges	Desurvire et al., 2004 Federoff, 2002 Prensky, 2001	Kiili, 2005 Sweetser & Wyeth, 2005	Malone, 1981 Federoff, 2002 Garris et al., 2002	Hunicke et al., 2004
Story/Narrative	Desurvire et al., 2004 Federoff, 2002 Prensky, 2001	Kiili, 2005	Desurvire et al., 2004	Hunicke et al., 2004 Amory & Seagram, 2003
Control/Interaction		Sweetser & Wyeth, 2005	Malone, 1981 Garris et al., 2002	Amory & Seagram, 2003
Feedback	Desurvire et al., 2004 Federoff, 2002 Prensky, 2001	Kiili, 2005 Sweetser & Wyeth, 2005	Desurvire et al., 2004	
Socialization	Prensky, 2001	Sweetser & Wyeth, 2005	Malone, 1981	Hunicke et al., 2004
Characterization	Desurvire et al., 2004 Prensky, 2001		Desurvire et al., 2004	Amory & Seagram, 2003
Mechanics	Desurvire et al., 2004 Federoff, 2002			Hunicke et al., 2004
Reward	Desurvire et al., 2004 Prensky, 2001		Malone, 1981	
Fantasy			Malone, 1981 Garris et al., 2002	Hunicke et al., 2004
Debriefing			Garris et al., 2002	
Persistence	Desurvire et al., 2004, Prensky, 2001			
Others	Prensky, 2001: fun, play, adaptation	Kiili, 2005: optimized cognitive load Sweetser & Wyeth, 2005: concentration, immersion	Desurvire et al., 2004 point of view Garris et al., 2002: sensory stimuli, mystery Malone, 1981: curiosity	Hunicke et al., 2004: sensation, discovery, expression, submission

Amory & Seagram, 2003: [1], Desurvire et al., 2004: [7], Federoff, 2002: [10], Garris et al., 2002: [11], Hunicke et al., 2004: [13], Kiili, 2005: [16], Malone, 1981: [19], Prensky, 2001: [23], Sweetser & Wyeth, 2005: [29]

3 The GREM conceptual model

In this section it is introduced a modular conceptual model (GREM – Game Rules scEnario Model) that supports EG design by providing a conceptual framework to specify the game. The model does not focus on the specific challenges and problems associated with any specific game genre, but it does compile general game features that are often regarded in the literature as significant in producing an engaging, fun and educational game experience, so that game designs have to be described in terms of these features. These descriptions can be implemented using the specific techniques and components of the particular genre the game belongs to.

The model assumes the principles of situated learning theory that stresses the idea of learning as a context-dependent activity [3]. This notion has been implemented in the model by differentiating two different and independent EG design views or sub-models: the game rule perspective and the scenario perspective (Fig. 1). In this way, the *game rule perspective model* describes the rules and rubric of the game, that is, how the game should be played. The *scenario perspective model* defines the virtual environment in which the game will be played, the interface provided to interact with it and the set of additional services available. The EG design will be obtained by matching elements of a specific set of rules with the elements of a scenario. Defining game rules and scenarios separately contributes to stress the importance of the scenario, which might otherwise be somewhat neglected when designed together with the rules. It also facilitates reusing game rules in different scenarios and vice versa. Furthermore, it allows for the design of games which emulate the way children design their games in real life, usually adapting and adjusting the general rules of a game in order to be able to play the game in different scenarios. For instance, to be able to play football in a small field or an indoor location, its general rules are often altered, adapting the number of players per team, the size of the field or the type of ball to what it is available or required at the moment. This approach can result in the definition of a variant of the original game (i.e. indoor football, goal-and-in).

The definition of the game rules and scenarios is carried out modularly, with the design entities distributed across different levels to denote that the definition of the entities at a specific level is based on the definitions of the entities at the innermost levels (Fig. 1). This type of organization facilitates building game rules and scenarios upon existing EG designs, for instance by replacing the definition of the uppermost layers of one perspective while maintaining the definition of the innermost ones. The selection of the types of design entities included in the model has been based on the frequency with which they are regarded as being significant in EGs in the literature (Table 1), and on the ease by which they can be made to correspond with specific components of a game design that can be reused. This way, the use of scores, prizes, and the possibility of personalising the avatar or unblocking new stages are solutions frequently used to implement a reward mechanism in a game which can be easily adapted and reused in a new game. On the contrary, fantasy is an aspect that intersects with many others, such as the design of the characters or the design of the virtual environment, and that is closely related to the subjective experience of the player. This makes it difficult to design reusable solutions for this feature, so it has not been included

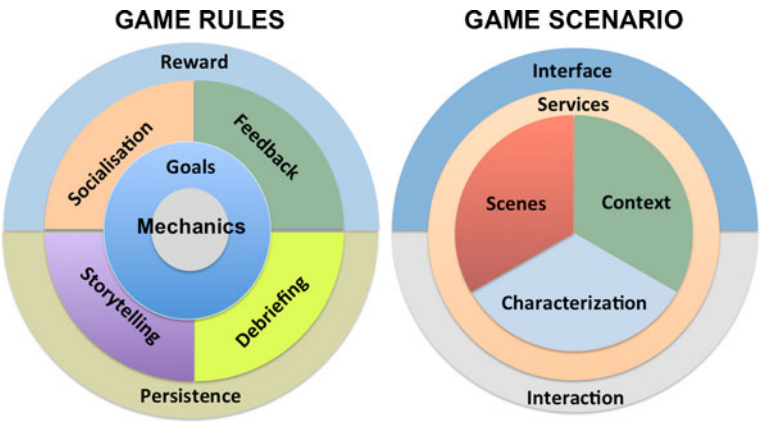

Fig. 1 Game rule model and game scenario model

in the model. Finally, some aspects closer to implementation such as the scenes, services and interface descriptions have also be included as they are aspects regarded as basic elements of a game specification [26].

The remainder of this section details the elements of these two sub-models depicted in Fig. 1.

3.1 Game rule model

The rule model allows the designer to describe how the game will be played. The model considers 4 different layers. As mentioned previously, this organization seeks not only to help guide the process of designing a game, but also to facilitate the adaptation of the previous design and to build new designs upon existing ones. This way, as elements of each layer are described on the basis of elements of the innermost layers the description of the game is carried out from the inside out, starting with the core layer, the mechanics, at which the basic elements and entities that participate in the game are described. Once these basics of the game have been defined the designer will go on to describe different goals to be achieved by those entities in the game. Note that the Goals layer appears on top of the game mechanics because by starting from a given definition of game mechanics it is possible to design many different games simply by replacing the definition of the goals proposed. Once the goals of the game have been defined, the designer can start defining the third layer of the EG design. This layer allows the designer to sequence and organize the goals into episodes of a story, to intersect those episodes with debriefing activities, to describe the feedback the player will obtain as a response to his/her actions and progress towards the goals and, in multiplayer games, to define the rules that govern the competition or collaboration in achieving those goals. Finally, the EG design can be completed by including some persistence and reward mechanisms. These components appear at the top layer of the model as designers might want to define rewards or store information not only about the state or progress of the goals, but also about the episodes completed, debriefing activity results, etc.

To adapt or reuse an existing EG design the process to follow will be the opposite. The definition of the outermost layer can be modified or replaced without changing the innermost layers. This allows the designer to replace the reward and persistence mechanisms of a game easily so as to adapt it to a new game profile, for example. Changes in the definition of the third layer might imply changes in the design entities of the fourth, but the definition of the two core layers will still remain unchanged. In general, whenever a designer adapts an entity on an specific layer, it might be necessary to propagate changes to other entity definitions placed on the layers which exist outside it, but it will not be necessary to introduce modifications to the elements at the innermost layers.

Next, the elements of the game rule model are explained in detail.

3.1.1 Level 1: Mechanics

As a first step in defining the rules of a game it is necessary to establish which will be the main elements or tokens that participate in it and the actions that will be available for execution. The core level of the model allows designers to define these basic game mechanics, which will determine the situations and events that might occur during the game. Mechanics are the *entities* that can appear in the game, their *state* and the *actions* allowed to perform over such entities. For example, a designer could describe a game in which the entities that participate are children, objects and boxes. Actions that are permitted include picking up objects and putting them into the boxes, and giving player the freedom to move around the game. Objects and boxes have an attribute that specifies their type and each of them can adopt two different states: ‘stored’ and ‘not stored’, for objects, and ‘full’ and ‘not full’, for boxes.

3.1.2 Level 2: Goals

The goals level is defined in terms of game *objectives* which can be associated with an educational purpose and be described as situations to achieve (*goals*) or to avoid (*fails*), and *restrictions* in the way the can be accomplished. For instance, an example of a *goal* for the game described in the previous section could be that "the children pick up the greatest amount of objects of a certain type". This *goal* can be associated with the learning objective "learn to identify", and it could be used in a game in which children have to find objects that might be the cause of an accident, for instance. Other examples of *goals* for the same mechanics could be "to make the child put the largest amount of objects in the corresponding boxes" or "to fill the largest amount of boxes". These objectives could be associated with the learning objective "learn to match", and could be used in a game in which children learn to recycle household rubbish, for example. Examples of negative *fails* could be "to avoid colliding with another child" or "to avoid putting an object in a box that does not match its type", and possible *restrictions* could be defined based on the number of objects required to fill a container or the time available to complete an objective.

3.1.3 Level 3: Feedback, socialization, storytelling and debriefing

The third layer allows designers to increase the complexity of the EG definition, enhancing its playability, educational properties and the players motivation. For instance, levels 1 and 2 only allow the designer to describe single player game experiences, as it is only possible to distinguish between entities controlled or not controlled by the player. By making use of the third layer the designer could introduce the notion of *roles*, *groups* and *synchronization rules,* which allow her to define different levels and types of *social interaction*. More specifically, *roles* can be used to specify the entities each player will control and the objectives they should try to achieve. The *groups* define associations within *roles* that establish the way they will contribute to the goals of the game (cooperation, competition or collaboration). Finally, the *synchronization rules* specify if the execution of the *actions* will be performed simultaneously or taking turns.

In addition, designers can also include *feedback information* that will be triggered when specific feedback rules based on *conditions* on the restrictions, goals, actions, and states of the entities are satisfied. The feedback could either have a motivational, guidance, or an educational purpose, and it could be presented in many forms, such as text, images or specific sounds.

The third level of the model also allows the designer to set the game in the context of a story using the *storytelling component*. The storyline will be conformed by a set of *episodes,* which organize the different goals specified at level 2, non-interactive multimedia *presentations,* that help reinforce the context of the action, and *storyline rules*, that define the order in which the *episodes* and *presentations* are presented to the player. For instance, continuing with the previous example, designers can specify a first episode which includes the goal "find objects of the specified type", and a second one in which players will be required to achieve the goals "put the objects in the corresponding box" and "fill the largest amount of boxes", simultaneously.

Finally, and in order to facilitate the connection of the lessons learned in the virtual world with their application in real life, designers could also require the player to complete some *debriefing* activities such as writing an essay, express his/her opinion in a forum or participate in a discussion about the game contents at specific points in the story-line.

3.1.4 Level 4: Reward & persistence

Finally, level 4 makes it possible to enhance the EG design with some mechanisms which, whilst not modifying the game logic, can have an impact on the EG playability, its difficulty or the player's motivation. For example, nowadays most games implement some sort of *rewards*, which can be described in terms of *recompenses,* such as the opportunity to play bonus episodes, obtain special prizes, or the accumulation of points, and *reward rules*, which activate the recompense and are defined in relation to the elements at the innermost levels, such as goals accomplishment, progress in the storyline, etc. In addition, designer can also specify different types of *persistence scopes*, (such as objective, episode or play scope), and *save* and *restore* break points. The *scope* determines the extent to which the status of certain elements of the game is maintained. For instance, the status of a game entity can be re-initiated at the beginning of each episode or, conversely, to persist even within different plays of the game. The use of *break points*, gives the players the opportunity not to undertake all the challenges in the same game session, but to be able to finish and resume the game instead as done in commercial games.

3.2 Game scenario model

The game scenario model allows designers to describe a virtual setting in which EGs can be played. The model considers three layers. The *representation layer* contains the description of a set of elements and assets that can be used to represent the entities defined in the game rules. The *services layer* defines a set of services to be used to support game activity. Finally, the *interface and interaction layer* describes the interface layout and the mechanics provided to interact with the elements of the game. As in the rule model, the definitions of the design entities on a specific level are based on the definitions of the design entities at the innermost levels. Following this schema, in this case the core layer of the scenario has been assigned to the *representation* layer, while *services* and *interface and interaction* layers have been placed above it. This organization highlights the fact that the outmost layers provide means to access, interact and enrich the design entities in the scenario. It also facilitates replacing or adapting an interface layout or an interaction mechanism to adapt the game to a different player profile or platform. The right hand side of Fig. 1 depicts a graphical representation of the model. Next, each of the layers will be detailed.

3.2.1 Level 1: Game representations

This level provides three different types of design entities, *scenes*, *characters* and *contexts*, which can be used to represent the elements of a game rules definition. A *scene* depicts a physical environment or situation in which the game action can take place, and it is defined through *scene-entities,* that the player can interact with, non-interactive *background* elements, that set the atmosphere of the scene, and *links* that activate transitions between scenes. For instance, in a scene that depicts a cave a designer can include scene-entities like treasure boxes, which could have a number of different states as open, closed, empty and full, background elements as stalagmites, and links between caves represented as wooden bridges.

Due the importance of including charismatic characters and avatars that the player can identify with in the game, this level also provides designers with a means of taking care of the definition of the characters that populate the scenes. These definitions can be described based in *character look components*, that establish the character visual appearance, and *psychological descriptions*, that cover aspects related to their personality, abilities, behaviour, etc.

Finally, designers can optionally enrich the scenario definition by associating them with *contextual elements* that would help to set the context of the scenes and its atmosphere through audio, animation, pictures or textual information resources.

3.2.2 Level 2: Game services

The second layer of the scenario definition allows designers to specify a set of *services* that will increase the possibilities of the games played within that scenario, and that are described through the set of *functionalities* they support. Examples of services frequently used could be messaging, chat, forums, message boards or ranking services. Designers can integrate a service within the game world representation by associating it with elements at a lower level of the model. For example, a voIP service can be activated through a scene-entity that represents a phone, and a messaging service with one that depicts a mailbox.

3.2.3 Level 3: Game interface and interaction

With regards to the interface, it is possible to distinguish between *containers* and *simple interface elements*. The former aggregates other interface elements and could be implemented as windows, frames or tabs, for instance. The latter could either be UI controls, such as buttons, check box or sliders, or be used to support the visualization of one of the elements of the innermost layers. The interaction mechanism can be described in terms of *physical interactions* performed using physical devices, such as a keystroke on the keyboard or a movement of the Wiimote, or to *virtual interactions* performed on the IU elements, such as to push a virtual button or to drag and drop an interface element. *Physical interactions* and/or *virtual interactions* can be combined and associated to *control commands* associated with specific elements of the scenario as the services.

As a summary, Tables 2 and 3 depict the design entities of the rules and scenario design perspectives.

4 Evaluation of GREM as a design tool

Since EGs have two different and complementary perspectives, the ludic and the educational one, their design process often requires the collaboration of different roles, such as game designers, educators and domain experts, each of them having a different background and technological profile. GREM provides a set of design entities described at a level of abstraction on the technical details that should make them easily managed and understood by each of the roles involved in this design process. In order to evaluate this potential utility of GREM as a tool to facilitate early design in multidisciplinary teams an EG design workshop was held with 32 participants: 10 game designers, 8 educators and 14 habitual players.

The workshop plan was as follows. First, a 30' training session was conducted in which features of EG were reviewed and GREM was presented. Next, participants were asked to design an EG for helping young students to learn basic concepts on computer programming. To carry out this task participants were organized in 7 groups ensuring that each group included at least one game designer, one educator and one player, and at least one domain expert, that is one person who had knowledge programming. To describe their designs each group was provided with two differently colored cardboards representing the rules and scenario perspectives of GREM as in Fig. 1, and post-its to create the design entities of their

Table 2 Design entities used for describing the rules perspective of the EGs

Rule model	
Mechanics	• *Entities*: game token defined through attributes and states. It might carry out actions and can either be controlled by the player or the computer. They are defined by: • *Attributes*: the characteristics of the entities are defined through pairs of attribute-value • *States:* describe the possible situations and conditions of the entity. • *Actions*: entities can perform actions on other entities and, conversely, also be the target of actions performed by other entities. The actions carried out and suffered might modify the *attributes* and current *state* of the entities.
Goals	• *Objective*: describe situations to achieve (*goals*) or to avoid (*fail*). Described through states and values of the attributes of the entities. • *Restriction*: limit on the actions that an entity can carry out, the values of its attributes or the states it might adopt.
Feedback	• *Feedback*: information provided about the game state or the actions carried out. It can have an educational or entertainment purpose. Defined by: • *Condition:* combination of values of actions, objectives, restrictions, entities' attributes and/or entities' states that trigger the feedback activation. • *Feedback entity:* defines the way in which the feedback will be presented
Socialization	• *Role*: defines a set of entities controlled by a player and the objectives to be achieved • *Group*: organize a set of roles specifying if they cooperate, contribute or collaborate in order to achieve their goals. • *Synchronisation*: specify if entities actions are triggered in real time or in turns.
Debriefing	• *Debriefing activity*: could either by individual or collective
Storyline	• *Episode*: stage or part of the game storyline in which a subset of objectives, entities, roles and groups take part. • *Presentations*: non-interactive multimedia elements used to set up the context of the story • *Storyline rules*: set of rules that define the way that episodes, presentations and debriefing activities are sequenced. They are described in terms of level of satisfaction of the episode objectives
Reward	Based on their performance in the objectives and their progress in the game storyline players can be awarded with: • *Prizes*: virtual items • *Scores*: accumulation of points • *Unlocks*: activation of special actions or access to unique episodes
Persistence	• *Break point*: define a point in the game in which the game state can be saved (*save point*) or retrieved (*restore point*) from previous plays. • *Conditions*: Combination of values that trigger the break point. They can be defined based on the achievement of rewards, satisfaction of objectives, progress in the storyline or directly by the player.

games that would be stuck in the appropriate parts of the cardboard (see right hand side Fig. 2). Participants were recommended to first define an initial idea of the game and, then divide the team in sub-groups, so they could work in the definition of different perspectives and design entities simultaneously. The session lasted approximately 60 min, and at the end, each group presented their designs and they were interviewed by a member of the research team. The interviews included questions about the level of satisfaction with the experience, the means provided to carry out the design, and about the approach the team adopted to complete the design task. To facilitate closer analysis, both the sessions and the interviews were video and audio recorded, respectively.

Table 3 Design entities used for describing the scenario perspective of the EGs

Scenario model	
Scenes	• *Scene*: representation of a physical environment containing
	• *Scene entities*: objects or areas of the scene that can be interacted with
	• *Links:* connections within two or more scenes
	• *Background elements:* non-interactive elements that set the atmosphere of the scene
Charac.	• *Character*: depicts a person or creature that can be interacted with and that it can appear in an scene
	• *Character-components:* depict clothing, body parts or instruments that conform the definition of the character
Ctx	• *Context-elements*: Non-interactive multimedia elements that help to set up the context of a scene
Service	• *Service:* tools and applications that provide support for carrying out certain activities associated to the game.
	• *Functions:* capacities that the service provides
Interface	• *UI element:* virtual element that provides a mean to interact with scenes and services or to represent its current state and output. They could classified as:
	• *Simple UI elements:* indivisible elements as text-areas, buttons, views and canvas.
	• *Containers*: UI elements composed of other UI elements.
Interaction	• *Device*: physical device used to interact with the scenario.
	• *Control command*: actions or combination of actions that the player performs in order to interact with the scenario. They can be defined based on:
	• *Physical interaction*: physical actions the player perform through a physical device
	• *Virtual interaction*: actions performed by the player on the UI elements

4.1 Results

With regards to the EGs designs, 4 out of the 7 teams that participated in the workshop completed full descriptions of the rules and scenario perspectives of their EGs; 2 presented game rules definitions and incomplete scenarios, and only 1 group was unable to finish any of the two perspectives of their game. The type of games designed varied, and included arcade games, such us shoot'em up, breakout or racing games, but also an adventure game in which the players fix elements of a devastated village. The narratives of the EGs were also diverse, and ranged from games with one single stage (3 EGs), to more complex storylines with several episodes (2 EGs), and one design which makes use of a mini-game approach. Finally, it is also interesting to note that most teams used scenario features to implement an instructional

Fig. 2 Designing EGs using GREM

purpose. For example, gates and keys of one game had associated pieces of code, so that only correct matches would unlock the corresponding path to the game. In another game, the enemy's spaceships adopted the form of operators and operands that the player should destroy in the specific order as dictated by a valid expression.

The interviews confirmed that the model was easily understood by the participants of experience, regardless their background and role in the design team. The means provided to carry out the designs seemed also to satisfy them, and the main objection was the very restrictive limit of time to accomplish the task. This impression seems somehow be related to the fact that 4 of the groups ignored our advice on dividing the work, and altogether carried out the design of the 2 EG perspectives in sequence. All the groups that presented incomplete EG designs followed this procedure.

4.2 Discussion

These results are encouraging, specially considering that it was the first time participants used the model, they didn't know each other in advance, and that the time to complete the tasks was very tight. Indeed, this seems to be the cause why some teams not finished their designs, as all educators, game designers and players that participated considered the model easy to understand and use. In addition, the experience also confirmed the completeness of the model, as it supported well the description of several EGs of different genres and narrative approaches.

The experience suggests that the model could be useful for supporting ideas generation in a multidisciplinary EG design team, as it provides a common vocabulary that members with different jargons can use to communicate. Furthermore, it also indicates that the separation between layers makes it possible to provide additional support in as much as each member can focus on the description of the design entities related to her area of expertise.

Finally, and with regards to the way the evaluation experience was conducted, it is necessary to highlight that no control group was considered necessary since the purpose of the experience was to confirm that the model could successfully support a multidisciplinary EG team on its tasks, and not to measure potential productivity improvements.

5 Designing social and situated games with GREM: the safety villages game case study

As a second kind of evaluation to assess the utility of GREM we used a case study that made it possible to explore the contributions of the model in a real project: the design of a collection of EGs aimed at helping to raise children's awareness of risks. A case study is defined as an empirical inquiry that investigates a phenomenon within its real-life context [32], and it is an evaluation method that complies with Design Science Research [12].

Children preparation on risks and emergencies is a non-formal process that takes place outside the schooling system and, therefore, it makes up a perfect scenario to test the model here presented. In this case, game designers have to combine knowledge on risks, learning and gaming to come up with a solution that is intrinsically motivating, since children will play it on their own decision. Since the model organizes the features most often regarded as significant in an EG experience, it could help to guide the design process, ensuring that no fundamental aspect or feature of the game is overlooked. In addition, and due to its modular organization, it is expected that the design entities produced can be reused to facilitate the definition of game variants. This will reduce the effort of having to produce each EG design from scratch. Next subsections describe three specific EG designs and some variants that were designed following GREM. The EG described were latter implemented using OpenSpace [21], an editor which

Fig. 3 Screenshot of the "Risky House!" game

allows the creation of Flash isometric virtual worlds that can then be released through SmartFox Server [28] engines. Screenshots of the final game implementation are provided in Figs. 3 and 4.

5.1 Designing games with GREM

The entities of GREM were used to design Safety Villages, a game based on a set of mini-games that children can play both in mono and multiplayer modes, and with or without the

Fig. 4 Screenshot of the games "Solve the risk", "Escape school" and "Escape to safety!"

supervision of an educator or adult. Games are intended for young learners of between 6 and 11 years old who access the EGs via a government emergency agency website. It was decided that point-and-click browser games would be most suitable due their simple mechanism of interaction.

The first game was called 'Risky house!' and it is aimed at helping children in identifying objects and situations that could be risky. The design of the game was based on the set of rules called "Look & Find" and the scenario "Family Home", whose definitions are summarized in Table 4. The rules describe the classic game in which players have to find specific objects or targets hidden in a place. The scenario depicts different rooms of a house in which some dangers and causes of domestic accidents are represented, such as an electric appliance in the bathroom, a wet floor, an unattended pan on the stove, etc. Once the set of rules and the scenario were defined, the entities of the two perspectives were associated with each other. It is

Table 4 Summary of the definition of the set of rules and scenario used in the game "Risky House!"

Rules: "look & find"	
Mechanics	• Entities: "PCE", "Target" (status "identified"/"not identified")
	• PCE Actions: "move" and "mark target"
Goals	• Goal (G1): PCE should mark all the targets
	• Restriction: Time limit
Feedback	• Condition: when target is identified
	• Feedback: information about the target founded
Socialization	• Role: player controls entity "PCE" and competes on goal G1
	• Communication: messages
Debriefing	• Collective activity (D1): list of all the target identified
Storyline	1. Non-Interactive: Intro
	2. Episode (Goal G1)
	3. Debriefing Activity (D1)
Reward	• Score: When target identified add 100 points
	• Prize: When G1 achieved add 1 "cup"
Persistence	• Save Point: per Play
	• Game State: prizes and number of plays
	• Recovery Rules: none
Scenario: "family home"	
Scenes	• Scenes: Kitchen, bathroom, garden…
	• Entities (risks): pan, wet floor,…
Characterization	• Characters: female kid, male kid, policeman
	• Components: body, head, hair, clothes…
Context	• Context element: Background music, video (children playing in different rooms of the house)
Services	• Services: messaging, zoom, character personalization . . .
Interface	• Views: scene, message display, …
	• Button controls: zoom, personalize character, music on/off
	• Text area controls: input message
	• Containers: scene canvas, character definition canvas
Interaction	• Physical int.: mouse(right click, move), keyboard (keystroke)
	• Virtual int.: select position (canvas), write (text area), press (button)
	• Control commands: select position (scenes), write (input message), press (buttons)

important to note that the rules specify the main components of the game and its basic entities in a high-level and conceptual way, in this case being a Player Controlled Entity (PCE) and some "Targets". By defining the rules in this way, it is possible to reuse them in many different scenarios. For instance, in one scenario the PCE could be represented by a "Pirate" and the "Targets" by "Treasures" the pirate should find. In the present example the PCE was represented by the character "Child" and the "Targets" by "Risks to identify". As a result, the players were offered a game experience in which they played the role of a child who has to find all the causes and origins of domestic accidents. When played in multiplayer mode players compete to identify more risks. Figure 3 depicts a screenshot of the game in which the final implementations of some of the design components have been marked. For example, the feedback of the game is provided to the player through the character of a policeman and the number of objectives accomplished is displayed in the right-hand corner of the screen.

Whilst for the youngest of children learning to identify risks and keeping them out of their reach might be enough, older ones may also need to be taught the best way to proceed in each case. Following this objective, a second game called "Solve the risks" was designed (see Table 5). The game was defined using a set of rules called "Look, Find & Answer" which was obtained reusing most of the elements of the "Look & Find" rules. This way, the mechanics of the new game rules establish that each time the player finds a target he or she must answer a question about it. New feedback rules were associated with these questions, and a new debriefing activity was given in which players are asked to remember the answers given during the game. In order to play the game in the "Family Home" scenario its definition was extended to include a new survey service that posed questions about the risks depicted in the scenes. During the process of merging the two design perspectives this new service was linked to the questions described in the rules definition. A screenshot of the game is shown in the top of Fig. 4.

In order to help children learn to identify the signs that depict evacuation routes a third game was designed. The game was produced by combining a new set of game rules called "Labyrinth" and a new scenario named "School". The rules described the classic game in which players have to find the exit of a labyrinth following some signs that show the evacuation route. The scenario describes different spaces within a school in which evacuation

Table 5 Summary of the definition of the set of rules and scenario used in the game "Solve the risk"

Rules: "look, find & answer"	
= Rules: "look & find" +	
Mechanics	• Entities: [. . .][a], "Question" (status "correctly answered"/"not correctly answered")
	• PCE Actions: "move", "mark target", "answer question"
Feedback	[. . .]
	• Condition: when question is answered
	• Feedback: information about the answer given
Debriefing	[. . .]
	• Collective activity (D2): list of all the correct answers given
Storyline	[. . .]
	• 4.- Debriefing Activity (D2)
Scenario: "family home"	
= Old "family home" +	
Services	• Services: [. . .][a] survey service
Interface	• Views: […] survey service view

[a] The reused original definitions of "Look & Find" and "Family Home" are not shown due to space restrictions

route signs and plans have been positioned. As summarised in Table 6, the game rules and the scenario were defined reusing many parts of the "Look & Find" rules and "Family Home" definition. By combining the rules and the scenario, players were offered a game experience in which they had to find the exit from the school following the path depicted on the evacuation route signs and the evacuation plan maps they found on their way. A screenshot of the game is shown on the left hand side of Fig. 4.

5.2 Designing game variants

Three sets of rules and two scenarios were obtained as a result of the design process of these three games. These rules and scenarios were easily reused in the design of 3 additional variants

Table 6 Summary of the definition of the set of rules and the scenario of the game "Escape School"

Rules: "labyrinth"	
Mechanics	• Entities: "PCE", *"Signs*[a]*", "Maps", "Exit"*
	• PCE Actions: "move"
Goals	• *Goal (G1): The PCE should find the "Exit"*
	• Restriction: Time limit
Feedback	• *Condition: when not on route to the exit*
	• *Feedback: recommendation*
Socialization	• Role: player controls entity "PCE" and competes on goal G1
	• Communication: messages
Debriefing	• *Collective activity (D1): list the signs found in the path the exit*
Storyline	• 1.- Non-Interactive: Intro
	• 2.- Episode (Goal G1)
	• 3.- Debriefing Activity (D1)
Reward	• *Score: When G1 achieved add 10 point per second remaining in time limit*
	• Prize: When G1 achieved add 1 "cup"
Persistence	• Save Point: per Play
	• Game State: prizes and number of plays
	• Recovery Rules: none
Scenario: "school"	
Scenes	• *Scenes: hall, classrooms, playground, garden..*
	• *Entities: signs, evacuation map frames,..*
Character.	• Characters: female kid, male kid, *teacher*
	• Components: body, head, hair, clothes…
Context	• Context element: Background music, videos depicting ordinary school situations
Services	Services: messaging, zoom, character personalization, *map service . . .*
Interface	• Views: scene, message display, …
	• Button controls: zoom, personalize character, music on/off
	• Text area controls: input message
	Containers: scene canvas, character definition canvas
Interaction	• Physical int.: mouse (right click, move), keyboard (keystroke)
	• Virtual int.: select position (canvas), write (text area), press (button)
	• Control commands: select position (scenes), write (input message), press (buttons)

[a] Normal characters depict reused elements of the "Look & Find" and "Family Home" definitions while italic characters depict new elements

of the original games. As can be seen in Table 7, by combining the set of rules for "Look & Find" and "Look, Find & Answer" with the "School" scenario two new games were obtained in which players had to identify and solve risks at a school. In addition, by matching the "Labyrinth" set with the scenario "Family home" a game in which players had to follow an evacuation route of a home was obtained. Although these combinations required introducing slight modifications in the original scenarios, such as adding risks representations to the school scenario, and evacuation route signs and a map service to the home definition, they were straightforward and quick to carry out. A screenshot of one of the game variants, "Escape to safety", is depicted in the right hand side of Fig. 4.

As a summary, it has to be highlighted that only the first game ("Risky Home") required defining a new set of rules ("Look & Find") and a new scenario ("Home"). Once this initial pair was obtained, the rest of the rules and scenarios were produced through the adaptation, modification and reuse of existing design components. Tables 8 and 9 gathers how components were reused for this purpose. As explained above, by recombining the 3 set of rules and 2 scenarios obtained as a result of this process, it has been possible to define 3 additional game variants. This allows us to conclude that the model supports the definition of EG designs easy to adapt and reuse and it suggests that the use of the model as a guide through the design process could help reduce the time required to complete the design of new EGs directly from scratch.

5.3 Evaluating the quality of the games

Once the design of the games concluded, the resultant EGs were implemented and evaluated. The objective of this evaluation was to complement the results of the previous experience by assessing if the games created satisfied both their educational as well as their entertainment purpose. The evaluation of this latter aspect is often dismissed in EGs, assuming that playing is always enjoyable. Unfortunately, in some cases the ludic experience elicited by some EGs is very limited [27]. In addition, the experience helped to assess the validity of the model, confirming the relevance of all the elements used in the game design descriptions.

The evaluation carried out was based on a case study conducted in a primary school in Madrid and consisted of a game session in which students played the EGs under the supervision and observation of their educators. The satisfaction of the entertainment objective of the EGs was assessed based on the student's perceptions through questionnaires at the end of the session.

The evaluation of the effectiveness of the intervention was based on the educators' opinions, who rated the educational value of the EGs in relation to the attainment of the three key learning objectives: to learn to identify risks, to learn the correct action to take for each of them, and to learn to identify and follow evacuation routes. This approach was preferred over

Table 7 Games produced as a result of the different combinations of set of rules and scenarios

Game Rules	Scenarios	EGs
Look & Find	Family Home	Risky House!
Look, Find & Answer	Family Home	Solve the risk
Labyrinth	Family Home	Escape to safety
Look & Find	School	Risky School!
Look, Find & Answer	School	Solve the school risk
Labyrinth	School	Escape the school

Table 8 Summary of reuses of design entities from the "Look & Find" rules

Game Rules	New components	Components reused from "Look & Find" rules		
		Modified	Extended	Identical
Look, Find & Answer			Mechanics Feedback Debriefing Storyline	Goals Socialization Rewards Persistence
Labyrinth	Feedback Debriefing	Mechanics Goals Rewards		Socialization Storyline Persistence

the use of the pre and post achievement tests, as the results obtained could have been compromised not only by the usual threads to validity associated with this method, such as the reactive effect of pre-testing [4], but also by the difficulty of ensuring that the sample of participants exhibited the same initial level of knowledge on the subject. This was due to the fact that, on the one hand, a pre-selection based on previous grades was not possible as education in emergency response procedures is not part of the standard curriculum. On the other hand educators would not allow us to select certain children to play the game based on their responses to an initial test as it would inevitably lead to some being excluded.

Finally, the relevance of the model elements was also assessed through the educators' opinions. Educators were considered candidates well equipped to carrying out this evaluation, since they are professionals who have a good knowledge of the preferences and likings of the target users of the games.

5.3.1 Experiment design

Twenty students from the 4th and 5th grades whose ages ranged from 8 to 11 years old and 8 educators collaborated in the study. In order to facilitate the observation of the experience the participants were organized in two groups of 10 students with 4 educators assigned to each.

The experiment was organized as follows: each group of participants was taken to the computer room where each child was assigned to a computer connected to the game server. In order to set up the context of the experience, students viewed a video illustrating the importance of being able to identify possible causes of accidents at home. Next, they were informed that they were going to play the role of "safety hero kids" who had to clean buildings of all kinds of possible risks and check their evacuation routes. After personalising their avatars and receiving brief instructions on how to play the games, students played two rounds of the games "Risky House!", "Solve the risk" and "Escape school" successively in multiplayer mode. The corresponding debriefing activities were also carried out collectively at the end of

Table 9 Summary of reuses of design entities from the "Home" scenario

Scenario	New components	Components reused from "Home" scenario		
		Modified	Extended	Identical
School	Scenes	Context	Services	Interface Interaction Characters

each play, and the total duration of each game session was 30′ approximately. During the course of the sessions the educators observed the experience, provided assistance to the students, explaining the instructions, solving misunderstandings, giving extra explanations about the consequences of the risks, and generally supervised the children. Figure 5 depicts some pictures taken during the experience.

5.3.2 Instrumentation

At the end of each session both students and educators were handed a questionnaire to fill in (Tables 10 and 11). The children's questionnaire (Table 10) was designed taking the "fun toolkit" as a reference or measuring fun with the children presented in [25]. The first question was an adaptation of the 'smileyometer' in the toolkit, and aimed to measure the reported fun, whilst the second question was concerned with the 'returnance' or desire to repeat the activity. In both cases this information was provided using a five point Likert scale accompanied by pictorial representations of each value range, as done in Visual Analogue Scales, which are specifically recommended for young evaluators [14]. The level of engagement in the activity was measured by direct observation, as recommended by the authors of the toolkit. Educators in turn were asked to rate the educational value of the experience, and the degree of relevance in an educational game of each of the design components considered in the proposed model (Table 11).

6 Results

According to the data collected from the questionnaires and depicted in Tables 10 and 11, both the entertainment and the educational objectives of the games were fulfilled. This way, with regards to the children questionnaire, the median values obtained for the question Q1, which students used for rating the level of fun, was 4,70, and the desire to play the games again, which could also serve as an indicator of how much fun the games were, is also considerable high, 4,50. These results match what was directly observed during the experience: children reacted positively to the game, and there were clear observable signs that they were having fun such as smiles, happy exclamations when they found a risk or won a game, excitement when the time or number of risks to identify was running out, etc.

With regards to the answers gathered from the teachers, there seems to be general agreement on the educational value of the games in relation to the three learning objectives (Q3=4,27; Q4=4,25; Q5=4,13). In fact, none of the teachers rated the educational value with

Fig. 5 Evaluation of the EGs at a primary school

Table 10 Answers to the students' questionnaires gathered during the users' evaluation

Fun						
"Please, answer the following questions:"	Answers					Median
	Not at all	Not good fun	Ok	Good fun	Very	
Q1 Was it fun playing the videogames?	0	0	0	6	14	4,70
	Not at all	No	Indifferent	Yes	Yes, very much	
Q2 Would you like to play the videogames again?	0	0	1	7	12	4,50

a score smaller than 4 to 5. In addition, the median values for the answers about the game design components are all between 4,12 and 4,25, which means that none of them are considered as being not relevant. Among them, 7 of the 8 educators rated the components of Socialization, Characterization, Reward and Persistence with the maximum value. This also matches what was observed during the experience, as children seemed to specially enjoy designing their own avatar, talk to each other about what happened in the game and, they cheered very much the fact that the messages they sent were depicted in the game as speech bubbles that came out from the avatars. This suggests that characterization and socialization could also be considered relevant features of a game by the children.

In addition, both children and teacher questionnaires included a last open question which participants were encouraged to use to describe changes to improve the games. Most of the children do not recommend any changes ("No changes", "It is fine as it is"). The ones who did suggest improvements focused mainly on the interaction mechanism ("make more easy to move the character", "better movement. To use the fastest computer"), and the reward system ("To be able to ex-change points by objects and clothes, or something like that"). The answers

Table 11 Answers to the educators' questionnaires gathered during the users' evaluation

Educational Value							
"Rate from 1 to 5 the educational value of the experience in relation to the following learning objectives:"		*1*	*2*	*3*	*4*	*5*	*Median*
Q3	*To learn to identify risk*	0	0	0	6	2	4,25
Q4	*To learn to take the right corrective action*	0	0	0	6	2	4,25
Q5	*To learn to identify and follow evacuation routes*	0	0	0	7	1	4,13
Game Design Components Relevance							
"Rate from 1 to 5 the degree of relevance of the following components of the design of an educational computer game:"		*1*	*2*	*3*	*4*	*5*	Median
Q6	*Feedback on actions performed and progress during the game*	0	0	1	5	2	4,12
Q7	*Socializing: support for social interaction*	0	0	0	1	7	4,87
Q8	*Storytelling: integrate the game in the context of a story*	0	0	0	4	4	4,5
Q9	*Persistence: give the opportunity to retrieve previous game states*	0	0	0	1	7	4,87
Q10	*Character: personalise characters and provide charismatic characters*	0	0	0	1	7	4,87
Q11	*Context: set the context of the action of the game*	0	0	0	6	2	4,25
Q12	*Services: extra services to enrich communication and ranking*	0	0	1	5	2	4,5
Q13	*Reward: include reward mechanisms such as score, prizes*	0	0	0	1	7	4,87
Q14	*Debriefing: activities to foster reflexion on what happened during the game*	0	0	0	6	2	4,25

obtained from the educators were even less critical and focused more on the procedure follow during the experience ("It would be better if the children first play the games individually and following compete altogether") than in the game itself. In any case, the direct observation of the experiment allows noticing a couple of problems that questionnaires did not capture. First, and as it was expected, younger children required some extra educational and technical assistance from the educators. This suggest that there is still room to improve the EGs if specific feedback for each player profile is included, and that feedback definitively constitute a relevant game feature for the player. Second, sometimes when children clicked the mouse too quickly too many times the game became blocked for a few seconds and did not respond to children actions, provoking some frustration. This suggests that the implementation of the interaction mechanism of the game can be improved, and it confirms that interaction not only is a relevant feature of a computer game but in fact a key factor for its success.

In conclusion, both educators and children showed a very positive response to the games, and the results of the questionnaires suggest that students learned while having fun. The latter point is highly significant and the high score of the educational value of the experience given by educators is also very encouraging. With regards to the validity of the model, and as explained in Section 2, it is well documented that most of those components are regarded by different experts as being significant in an experience of these characteristics. The educators judgements served to corroborate those assumptions as they rated all the design components as highly relevant in an EG, thus confirming its validity.

7 Conclusions and further work lines

We have proposed a conceptual model that organizes the features most often regarded in literature as significant for an EG. The evaluations carried out confirmed the semantic quality of the model, that it can successfully support the design of EGs that fulfil both the entertainment and ludic purpose, and that it facilitates obtaining EG designs that can be easily reused and adapted. Furthermore, unlike other proposals that only tackle the design of games of specific genres, the model is general enough to support the design of different game types, as it is possible to specify sets of design entities for the description of each feature different to the ones used in the games described here, and that can satisfy the special requirements of a specific game genre. Moreover, the model was used by multidisciplinar teams that considered the model easy to understand and use.

In any case, these conclusions have to be framed in the right context in order to avoid misinterpretations. It is necessary to stress that we do not claim that use of the model guarantees the automatic success of the EGs produced, just the same as the use of an educational modelling language does not always guarantee the quality of the learning process. Since GREM includes components to deal with relevant features of the learning process (such as the use of narratives, rewards, debriefing activities, socialization) it can help EG designers to take them into account since the beginning of the project as a basis to support early ideation. Additionally, since the model makes it easier to reuse design entities, it can be used as a guide through the design process that could help to reduce the time required to complete the design as opposed to design the EGs from scratch. The results of the two evaluations carried out, the design workshop and the case study, confirm these contributions of the model.

However, to demonstrate the utility of the model in terms of productivity improvement, it would be necessary to carry out further evaluations that will involve developing design methods and tools based on the model that can be compared with other design approaches. Our current lines of research go in that direction. Once the model has been evaluated our next

concern will be supporting the production phase, so that not only the time and costs associated to the implementation of EGs can be reduced but also domain experts and educators are relieved from the need to ask for technical assistance when defining their own EGs.

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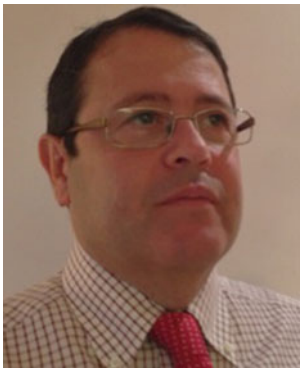

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