Towards Modeling Educational Objectives in Serious Games

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Abstract. When developing serious games the most complex task is the alignment of instructional teaching methods and the game itself. To address this issue, we propose a shared language modeling approach for educational instructors and game developers. The language is based on so called serious game bricks, composites and rules. Combining these pedagogical and story elements allows the domain experts to create serious game patterns. The use of those patterns supports the development of serious games that are both entertaining and present specific educational objectives.

Keywords: serious games, educational objectives, modeling language, pattern, game development

1   Motivation

In many different educational settings, increased usage of digital games to support learning can be observed [1]. The entertaining nature of games incite and motivate users to learn and exercise, and furthermore they can increase the effectiveness of learning processes [2]. Learning objectives are integrated within games, so that users can reach these playfully and learn simultaneously [3]. These games are called serious games. They encompass digital games which entertain and, at the same time, educate or instruct the user [4].

Harteveld et al. state that during the development process of a serious game the toughest challenge is the alignment of learning content and the game itself [5]. Adding to that, game developers need to integrate pedagogy into the digital games' story [6]. Greitzer et al. state that a systematic engineering method is needed to build, understand and analyze serious games, and especially to focus "on pedagogical approaches that provide effective, relevant, and motivating learning experiences" [6]. This position is supported by Zyda, who states a practice to insert learning opportunities into stories needs to be developed and "research must focus on combining instruction with story creation and the game development process" [4].

To facilitate and stimulate the up to now relatively unstructured transition of instructional teaching methods to serious games, we propose a shared language modeling approach between the domain experts, i.e. instructors and game developers, in-

volved. Our aim is to connect both domains to produce reusable patterns for serious games, which enable learners to achieve predictable learning successes in a playful manner. Consequently, the shared language is intended to meet the following goals: (1) Standardize, clarify and simplify the communication between instructors and game developers, (2) create a formal description of patterns to achieve learning objectives within serious games, (3) allow the reusability of the prior mentioned patterns.

The structure of this paper is as follows: Section 2 provides relevant work. Section 3 presents the proposed modeling language. Finally, section 4 presents conclusions, limitations and future work.

2   Related Work

In scientific literature, a plethora of different approaches for developing serious games can be found lacking a standard model. Harteveld et al. base their game development about levee inspection (Levee Patroller) on underlying design and learning theories [5]. They conclude that three components must be taken into account during serious game development: pedagogy (learning), game (fun) and reality (validity). Their main focus during development lies in matching game contents to pedagogical methods. Kelly et al. developed a serious game (Immune Attack) for teaching immunology [7]. Their approach focuses on three research challenges: game design, integration and multiple scales. Furthermore, learning objectives were used to specify learning outcomes and were connected to gameplay. Muratet et al. have designed and developed a serious game to improve programming skills. In a first step the authors examined what kind of digital game is suitable for the task [8]. In the next step the game was developed based on learning objectives from different points of view to evaluate the learning success. The authors state a learning process will occur, if a serious game is attractive, fun, stimulating, and encourages the player to progress.

While differing in many aspects during development, all three cases highlight the need for a pedagogical approach interwoven within the story of a serious game to achieve and evaluate the learning outcomes. Educational objectives (also known as instructional goals) are outcome statements describing the knowledge, skills and/or attitudes learners have gained upon completion of instructional units. They can be utilized to design instructional units to ensure the focus on learning outcomes. Furthermore, they can be used to communicate instructional aims to learners and serve as a basis for the evaluation of the learning success.

A modeling language is required to develop processes with predictable learning outcomes and to standardize the communication between domain experts. Basically, a modeling language is a Domain Specific Visual Language. Compared with general purpose languages, these languages allow the description of solutions for a problem at the level of abstraction of the domain. A modeling language consists of syntax and semantics. The syntax has elements and rules to construct a correct model. The elements are the building blocks of the modeling language, whereas the rules determine the syntactically correct combination of the elements. The semantics depicts the meaning of the combination of elements or model as a whole.

3 A Modeling Language for Educational Objectives in Serious Games

In this chapter we propose a modeling language that allows the description of pedagogical goals and story aspects for the serious game development process. Our aim is to enable instructors and game developers to combine teaching methods and story elements to obtain reusable serious game patterns for specific educational objectives. As a result, these patterns can be used by game developers as best practices during the development process to ensure predictable learning success in serious games.
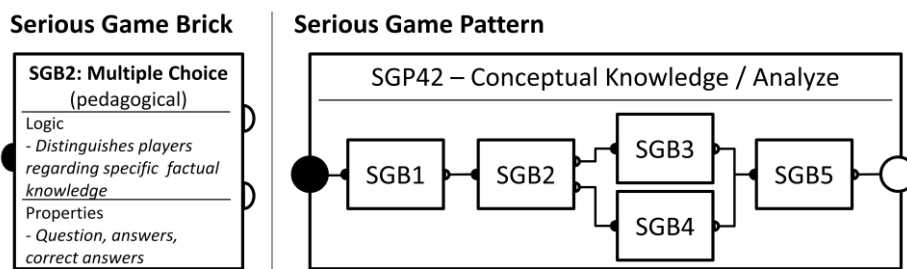
Serious Game Brick | **Serious Game Pattern**

SGB2: Multiple Choice
(pedagogical)
Logic
- *Distinguishes players regarding specific factual knowledge*
Properties
- *Question, answers, correct answers*

SGP42 – Conceptual Knowledge / Analyze

SGB1 → SGB2 → SGB3 / SGB4 → SGB5

Fig. 1. Serious game brick and pattern (source: own representation)

The modeling language consists of connectors and two kinds of elements: serious game bricks and serious game composites. Connectors describe the control and information flow between elements. Whereas a serious game brick (SGB) represents an indivisible, basic entity of a serious game which fulfills either a pedagogical or a game function. Bricks consist of a name, description, classification, in-/output sockets, logic and properties. The classification specifies whether the SGB fulfills pedagogical or story functions. The in-/output sockets can be used to establish connections using connectors between SGBs. A brick receives data through an input socket, processes the data and sends it updated via the output socket to another element. The logic describes how the data is processed and describes the function of a SGB. Properties are interchangeable parameters to adapt the logic (see Fig. 1). The other elements of our modeling language are called serious game composites (SGC). These elements are representations of a combination of two or more connected bricks to encapsulate several indivisible functions to one reusable complex function. Like a SGB, a composite also consists of a name, description, in-/output sockets and properties. When SGCs achieve educational objectives through integrated instructional teaching methods, then this special kind of composite is referred to as a serious game pattern. By using the revised Bloom's educational objectives taxonomy [9] we apply a knowledge dimension (factual, conceptual and procedural knowledge) and a cognitive process dimension (e.g. apply, create) to each pattern, to define the scope and field of application. To ensure a high degree of reusability, the patterns neither contain learning nor game contents. These contents will be added when applying the patterns.

Basic rules were established, such as an output socket must be connected to an input socket. Each element is connected to at least one input and one output socket. The first and last elements are connected to special start and end elements. Furthermore,

following the aspect of a story driven design for serious games, two as pedagogical classified SGBs should not be placed after each other.

4   Conclusion and Outlook

The objective of this paper is to allow domain experts to create serious game patterns, which combine instructional teaching methods with story elements. We have shown that existing game design approaches highlight the importance of a pedagogical approach in serious games. Therefore, we presented first steps towards a shared modeling language for the domains' pedagogy and game development. The language is based on serious game bricks, composites and rules. We also proposed serious game patterns, a combination of bricks and composites which leads to the achievement of learning objectives. This paper raises several issues for further consideration. First, research is needed to identify the key serious game bricks and modeling language rules to support either pedagogical or story objectives. Second, Bloom's revised taxonomy needs to be assessed for its suitability as a classification. Third, a tool support needs to be implemented and a process developed which enable instructors and game developers to use the modeling language to jointly create and modify serious games patterns. Finally, a tool is needed to develop serious games based on the presented serious game patterns.

5   Bibliography

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