SimSYS approach: a Model-Driven Requirements Engineering for Serious Educational Games.

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Group 2
**Introduction**

The description is based on “Toward Model-Driven Requirements Engineering for Serious Educational Games: Informal, Semi-formal, and Formal Models” by (Cooper, Nasr, & Longstreet, 2014).

The paper of (Cooper et al., 2014) is about a Model-Driven Engineering (MDE) approach for games, it is a three step-model (Figure 1) approach for developing Serious Educational Games (SEGs) called the simSYS approach.

SEGs are games providing a fun environment to the pedagogical aspect, putting the player in an immersive stage forcing him to think in order to overcome obstacles to achieve his goal(Gee, 2003). The goal of this approach is to improve SEGs and to involve game developers, educators, and software engineers making it possible by providing an elaborated step for each discipline. This is done by detailing three steps, transformation from model to another, and providing revision at each step to the previous one.

![Figure 1: Overview of models in the SimSYS approach (informal, semi-formal, formal) adapted from Cooper et al. (2014)](image-url)

The three steps of the method are:

1. **Informal**: it is the way to put in words, textually the learning objectives and game play of the SEG requirements including to it the user interface concepts (e.g. audio etc.). To summarize, this step gives the overview of the game and the rules needed for the play.

2. **Semi-formal**: this step is the transition from the informal model. The narrative part is evolved to an adapted Unified Modeling Language , Use Case (UML UC) model

3. **Formal**: it represents the executable part. After collecting the tabular from the semi-formal representation of the games they can be transformed to an XML file used for simulations and revisions. Errors are detected and iteratively corrected to the previous steps both in the formal and semi-formal model.

The paper is written by Doctor Kendra M.L Cooper from the University of Texas, Dallas, U.S.A who focusses her researches on serious games with component-based system, software engineering and engineering education.

The second author is Eman S.Nasr, an independent researcher from Cairo Egypt, who has written papers on Requirements engineering for software quality or visual notation. And the final author is
Christopher Shaun Longstreet, the director of the center for teaching and learning at the Marquette University, Wisconsin, U.S.A, who focuses on game education researches.

Example

(Cooper et al., 2014) has provided a case of a test game. To show how the method works we are going to provide an example of SEG.

Our game is about getting knowledge on geography. It will be a quiz about flags, capitals etc.

Below we will describe each model for this game (Figure 2) in details.

![Diagram of simSYS approach in our game](image)

**Figure 2: overview of the simSYS approach in our game**

1. **Informal model:**

   The informal model is the narrative description of the game we will propose for the example (Figure 3). We find the essentials elements of a game; the title of the game, an overview description of what the game will be constituted and basic rules (Adams, 2013).

   **Title:** Learn Geography

   **Overview:** The game consists of one act with 5 scenes each scene represents a different continent each scene has 2 presents. The first scene has three challenges: in the first challenge the player has to match the shape of the country with its name, in the second challenge the player has to match the flag to the appropriate country in the map, the third challenge is a quiz about the capitals of the countries in the chosen continent. In each challenge there is an introduction, several questions and background music for right or wrong answer. The second screen gives the score accumulated by the player.

   **Initial conditions:** The score is started at 0 points. The player can choose which continent to begin with and have to answer to the maximum questions in 1 min for each challenge.

   **Game rules:** The player gain 10 points with right answers. A score above 200 needs practice, a score around 200-299 is average, a score around 300-449 is good, and a score of 450 is the master of geography.
2. Semi-formal model:

The example will be focused on this part of this approach; the transformation from the formal (narrative) to the semi-formal happens iteratively. UML is for visualizing, constructing, and documenting the process of software (Mishra, 2008).

According to (Cooper & Longstreet, 2012b) the game requirements modeling approach consists of tailored visual use case diagram, tabular specification templates, and an underlying formal representation of the requirements model.

Our game has one act, 5 scenes, each scene has 2 screens, and the main screen has 3 challenges. We present the details in (figure 4) the visual use case model.

![Figure 4: Semi-formal Tailored Use Case Model (visual UML diagram)](image)

Each graphic use case has a detailed tabular specification: text, graphic, and audio etc.

The requirements model can be viewed from multiple perspectives (viewpoints): the instructor view; administration/accreditation views; game designer view, game developer views; and game player view (Nuseibeh, Finkelstein, & Kramer, 1996).

To present the tabular we are going to detail the tabular of the Flags Challenge for the scene 4 “Europe”. It is organized into different sections. In the tabular we find the Identifier, Purpose, Learning Objectives, Characters, and Style. This is followed by the Elements (questions, answers, evaluation, and feedback) and the Reward Scheme. Followed by the mechanics with the timers for the challenge. And finally the order of the Elements in the quiz (Nuseibeh et al., 1996). Below (Table 1) is a partial presentation of our tabular for one scene (scene 4) representing the geography of Europe.

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Flags challenge – section Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>This part of the game Challenges the player to</td>
</tr>
</tbody>
</table>
Learning objectives
Challenges the student on her/his knowledge on foreign countries and their flags with interactive.

Elements
Question: Match the flag in the map.
Level of difficulty: initially easy, gets more difficult deeper in the challenge.

Reward Scheme
10 points gained with every correct answer.
Nothing happens if the answer is incorrect.

Characters
A geography Teacher is introducing the question.

Style
Layout: Character asking the question, providing feedback on correct or incorrect answer.
How to answer: Player touches the screen on the right field to score.
Size: full size. The map can be zoomed in or zoomed out.

Timers
The player has one minute to match a maximum amount of flags.

Order
First Flag: common country, well known
Second flag: less known country …

Table 1: Tabular Specification of the flag challenge-section Europe

3. Formal model:

All the tabular specification of the game are transformed into a single XML file that can be tested in the SimSYS Game Play Engine. The Game Play Engine is being developed using a test driven approach, in which a collection of test games have been specified to systematically develop and extend the architecture, design, and implementation of the engine (Cooper & Longstreet, 2012).

XML provides a mechanism to impose constraints on the storage layout and logical structure to describe the behavior of computer programs (W3.org, 2008).

Process description of the Method

1. Description:

The Process Deliverable Diagram of the SimSYS approach is divided in 3 steps. The first step is the informal Model which is represented by a narrative description of the game made by the designers: overview, title, rules, and initial conditions that meet the requirements of the game. The second step is the transformation to the semi-formal model. This step is provided by the game developers and designers which consist on providing UML UC diagrams and templates of the game. This step will be further detailed later because it’s the technique we are discussing in our paper. The third step is the transformation from semi-formal model to formal model. The game developers produce a XML file according to all the game requirements from the previous steps to be tested and provide revision and corrections.

2. Process Deliverable Diagram:
3. Activity and Concept Tables of the Method

<table>
<thead>
<tr>
<th>Activity</th>
<th>Sub-Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the Game</td>
<td></td>
<td>In the informal model a description of the game is needed. It is the first step, to</td>
</tr>
</tbody>
</table>
introduce the game with a narrative capture. This allows the game designers to focus on the creative aspects of the game play.

Transform to the Semi-Formal Model

Describe Elements

In order to create the UML UC diagrams and Tabulars for the game the designers have to describe elements needed for the game. This part will be further explained in the Technique.

Create a Visual Model

The first step of transforming the informal model to the Semi-formal Model, consists of creating a UML UC for the game.

Create Tabular Model

A template based representation, Tables presenting the specification of the development, and maintenance of the game.

Transform to the Formal Model

Create XML File

The first step of the transformation from Semi-Formal to Formal Model. The game developers create an XML File from the UML UC and the Tabular in order to test the specifications of the game.

Load the Game

The Game is Loaded in the SimSYS Game Play Engine in order to play it and test it. The goal is to try the game and find out if all the specifications stated in previous steps are correctly stated.

Check and Correct Errors

At the end of the testing part, all errors and missed specifications are stated. The reviews and the errors are corrected in both formal and semi-formal model.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAME REQUIREMENTS</td>
<td>Production GAME REQUIREMENTS and pre-production game designs (Adams, 2013)</td>
</tr>
<tr>
<td>NARRATIVE DESCRIPTION</td>
<td>A NARRATIVE DESCRIPTION is used to introduce the specifications of a game in words such as Title, overview, and rules to every part of the team working on the project (Bethke, 2003)</td>
</tr>
<tr>
<td>UML UC</td>
<td>Visual and Tabular Template Based Specification</td>
</tr>
</tbody>
</table>

Table 2: Activity table related to the PDD of the SimSYS Approach
Process description of the Technique

1. Description:

This PDD describes the Technique we chose to detail in the paper; the transformation from informal to semi-formal model is the second step of our method. It consists on a presentation of UML UC as visual Models (USE CASE) and Tabular Model. These UML UC diagrams and tabular describe the elements of the game; scene, act, screen, challenge.

2. Process Deliverable Diagram:
3. Activity and Concept Tables of the Method

<table>
<thead>
<tr>
<th>Activity</th>
<th>Sub-Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transform to the Semi-Formal Model</td>
<td>Define elements</td>
<td>The game design elements presented by the game designers gives a motivation to the users to learn something with a game perspective.</td>
</tr>
<tr>
<td>Create Visual Model</td>
<td></td>
<td>This Activity Creates the Use Case for the model of the game. Describing the part of the game which is divided in Acts, Scenes, Screens, and Challenges</td>
</tr>
<tr>
<td>Create Tabular Model</td>
<td></td>
<td>This is the Su Table presenting the Specification of the game. A unique template is given for each part (Act, Scene, Screen, Challenge)</td>
</tr>
</tbody>
</table>

Table 4: Activity Table of the Technique

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELEMENTS</td>
<td>The use of game design ELEMENTS in non-game context increases the human-computer...</td>
</tr>
</tbody>
</table>
interaction. That gives more motivation to the users to focus in the serious game (Deterding, 2011)

<table>
<thead>
<tr>
<th>USE CASE</th>
<th>A USE CASE is a description of the interaction between the actor and the action/environment of the game (Bertolino et al., 2002)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABULAR MODEL</td>
<td>A TABULAR MODEL consists in specifications in sub-tables in order to define and maintain the design (Pollack, Hicks, &amp; Harrison)</td>
</tr>
<tr>
<td>ACT</td>
<td>This is how the game in SimSYS is designed, each part could has one or more learning objectives and each learning objective has one or more learning taxonomy category (Jayaraj, Raiker, Cooper, &amp; Longstreet, 2014) Every game has at least one ACT. One act is divided in one or more SCENE (Cooper et al., 2014)</td>
</tr>
<tr>
<td>SCENE</td>
<td>Could has one or more learning objectives and each learning objective has one or more learning taxonomy category (Jayaraj, Raiker, Cooper, &amp; Longstreet, 2014) One SCENE is divided in one or more SCREEN (Cooper et al., 2014)</td>
</tr>
<tr>
<td>SCREEN</td>
<td>Could has one or more learning objectives and each learning objective has one or more learning taxonomy category (Jayaraj, Raiker, Cooper, &amp; Longstreet, 2014) One SCREEN is divided in one or more CHALLENGE (Cooper et al., 2014)</td>
</tr>
<tr>
<td>CHALLENGE</td>
<td>Could has one or more learning objectives and each learning objective has one or more learning taxonomy category (Jayaraj, Raiker, Cooper, &amp; Longstreet, 2014) A CHALLENGE is one the phases of the game (Cooper et al., 2014)</td>
</tr>
</tbody>
</table>

**Table 5: Concept Table of the technique**

**Template**

1. **Description**

The template we used in our example is a Tabular specification of a Challenge, an element of the game. The tabular is used as UML UC model and presents keys for the designers to link from the informal model, the narrative description, to create the XML file in the last step.

It is composed of:

- **Identifier**: name of the challenge
- **Purpose**: the purpose of the challenge
- **Learning objectives**: what are the objectives the students must acquire when they play the challenge.
- **Elements**: what the challenge will be composed of.
- **Reward scheme**: how the scoring is ranked.
• Characters: the avatars or actors in the game challenge.
• Style: the user interface and layout of the challenge
• Timers: the time to play the challenge.
• Order: a description in how the game takes place from the beginning till the end

2. Example Template

You can find the template in this link

Related Literature
Serious educational games (SEG) present a fun environment while the player has to use his mind capacities. This makes the SEGs complex application requiring multiple expertise. Game development approaches are mostly document-centric. However the approach studied in the paper is originated from model-driven engineering (MDE) approach that integrates elements of traditional game design, pedagogical content, and software engineering methodology (Gloria, Bellotti, & Berta, 2014).

(Winn, 2007) depicts different frameworks to the development of SEGs such as The Mechanics, Dynamics, and Aesthetics (MDA) framework and The Design, Play, and Experience (DPE) framework presenting a relationship between designer and player. Those frameworks are directly controlled by the designer. These frameworks could be related to the informal model of the SimSYS approach.

(Matallaoui, 2015) illustrate a model-driven approach for defining gamification and building blocks of serious games; however the gamification modeling language is for unity-made serious games, when SimSYS engine uses XML files for this.

As a result of the study of (Cooper et al., 2014) to make an interdisciplinary approach, they introduce a prototype made to automatically generate the formal models seeking at the same time additional validation for their future work.

References


Multimedia, Educational and Serious Games, 208–212. http://doi.org/10.1109/CGames.2012.6314577


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