Towards the Support of Scaffolding in Customizable Puzzle-based Learning Games

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Abstract—Serious games can be used as learning tools since learning games are more in correspondence with the current generation of students, foster students’ motivation, and increase the learning effects, making learning meaningful to students. This paper presents a conceptual model for representing designs coming down to a puzzle-based game implementing an active learning method that describes the activities flow for learners. Each activity refers to a collection of puzzle pieces needed to perform the activity. In order to support the performance of individual activities, micro-scaffolding support, such as question or hints, can be also defined using our proposed model.

Scaffolding; Puzzle-based game

I. INTRODUCTION

Many authors believe that the current generation of students is different from former generations due to the changes in their media consumption patterns. New educational approaches are required to be in correspondence with these students [2, 9, 11]. For this reason, many studies have indicated that traditional educational approaches need a shift to new pedagogical techniques based on constructivist learning theories [4]. In that sense, serious games are being proposed in the technology enhanced learning research domain as potential learning approaches that foster students’ motivation, increasing the learning effects, making learning meaningful to students and creating a learning culture which is more in correspondence with students’ interests [6]. Frequently-cited arguments held by researchers for using serious game in education are: (a) they can invoke intense engagement in learners [12], (b) they can encourage active learning [3], (c) empirical evidence shows that games can be effective tools for enhancing learning and understanding of complex subject matter, and (d) computers games can foster collaboration among learners [5]. Besides, games that encompass educational objectives and subject matter are believed to hold the potential to render learning of academic subjects more learner-centred, easier, more enjoyable, more interesting, and, thus, more effective [7, 10]. One particular type of games in this area is those based on puzzles since subject-matter specific concepts can be easily represented as puzzle pieces.

Regarding the learning process, providing guidance to students has been seen necessary to enhance their learning experience. In that sense, scaffolding techniques are often needed to help students succeed in their learning and to achieve the expected learning outcomes [15]. Scaffolding techniques are processes, such as coaching through prompts, templates and guides, tools or strategies that teachers implement in order to support a student, that thoroughly guide students towards the successful completion of a learning activity [14]. In particular, within the Information and Communication Technology (ICT) area different scaffolding techniques have been indentified [8]. Namely: social-guidance and system-guidance scaffolding, depending on whether an individual or a tool is the responsible of providing support to students; macro-scaffolding when pedagogical methods defines activities flows, or micro-scaffolding when the support is provided to perform specific activities; and tool-enveloped scaffolding, when a tool is used as part of a scaffolded learning process, and tool-embedded scaffolding when the scaffolding is applied within a specific supporting tooling. Furthermore, within this context it has been noticed that [8]; a) there is a lack of ICT-devoted tools satisfactorily implementing active learning methods and, as a consequence, instructors themselves provide this support to students; b) current tools may not be flexible or adaptable enough to address specific learning tasks related to ICT education (i.e. they lack on micro-scaffold students during the learning process); and c) having an ICT-devoted system integrating macro-scaffolding and micro-scaffolding seems to be very difficult to achieve since the predominant solution is to envelope ICT-devoted tools in a general approach and to delegate teachers the provision of micro guidance.

Taking these facts in consideration, we propose a conceptual model to design serious games (in concrete, puzzle-based games) that combine macro- and micro-scaffolding. The final aim is that teachers, provided of authoring tool compliant with the model, will be able to create their own puzzle games embedding scaffolding. The remainder of the paper is organized as follows. In Section II, the conceptual model is presented by defining the requirements it should fulfil and by describing its main elements. Section III presents some learning scenarios, within the ICT area, which can benefit from the use of puzzle-based games. Finally, Section IV presents the conclusions and future work lines derived from this work.

II. MODELING SCAFFOLDED PUZZLE-BASED GAMES

The objective of this conceptual model is to provide a framework of elements that can describe the design of puzzle-based games implementing macro- and micro-scaffolding support to learners.
The conceptual model is expressed as a set of UML class models and a definition of the vocabulary used. In concrete, there are two basic models: an aggregation model and a structure model.

A. Aggregation Model

Figure 1 represents the aggregation relationships and the specializations of abstract classes of the conceptual model showing that a puzzle-based game design provides scaffolding approaches and integrates different puzzle pieces responsible for solving the different learning activities.

The model shows two levels of semantic aggregation (the two horizontal layers of grey coloured classes). The semantically highest level is the puzzle-based game which aggregates a collection of components, scaffolding approaches, and objectives.

On the one hand, a scaffolding approach can be classified in macro-scaffolding or micro-scaffolding, depending on the granularity level of the learning process where it is applied. In that sense, macro-scaffolding can be defined by an active learning method (e.g. Problem-based learning, Inquiry-based learning, Cognitive apprenticeship, etc.) or other teacher’s strategy (e.g. increase level of difficulty). Micro-scaffolding, on the contrary, can be implemented as a hint, question prompt or other resource to provide specific support to students performing concrete tasks.

B. Structure Model

This model emphasises the functional relationships between the classes (see Figure 2). The core of the puzzle-based game design is that macro- and micro-scaffolding approaches are provided to students. Macro-scaffolding is provided in a way of an active learning method which defines the activities flow of a game. Each activity has a score. Students have to play with different puzzle pieces in order to construct or design a solution to solve a specific activity. Micro-scaffolding, on the other hand, could be provided to students in order to guide them to achieve a correct solution of a concrete problem. These support approaches could be implemented as a hint or a question.

III. APPLYING PUZZLE-BASED GAMES IN DIFFERENT LEARNING SITUATIONS

Teachers can apply the presented conceptual model to support the learning of subject-matter specific concepts and skills by means of puzzle-based games designs.

The proposed conceptual model defines a generalization of these puzzle-based games to allow the opportunity of designing different games to specific-subject matters. More specifically, the learning process (i.e. activities’ flow) could be defined by an active learning method in order to guide students during the different activities (i.e. macro-scaffolding). Each activity will be related to different puzzle pieces that students should join to reach a solution. Specific-purpose mechanisms, such as questions or hints, can be provided to help students during the building process (i.e. micro-scaffolding). Furthermore, there will be a limited number of attempts to reach a specific solution and a feedback will be provided to students at the end of the game.

For instance, ICT that is suffering a decreasing interest by students in the enrolment of the studies related to this area [1, 13] may benefit from the use of this kind of puzzle-based games in schools and higher education to increase the...
students’ interests and motivation towards this field. Besides, since most of the subjects in ICT engineering education are primarily characterized by learning about concepts and the relations among them, puzzled-based game could be apply by representing concepts as pieces of a puzzle. Hence, the use of puzzle-based games may provide a good opportunity to foster students’ motivation and to deal with the needs of different ICT educational situations.

Some examples to apply this approach in ICT engineering education can be: a) Programming Fundamentals, where blocks of programming instructions can be designed as specific puzzle pieces that students must join each other to reach a solution for a proposed program; b) Computer Architecture, where different activities related to learn about Boolean logic or von Neumann architecture can be design as a puzzle-based games where puzzle pieces becomes different logic gates, CPUs, Control Units, Arithmetic Logic Units, Memories, etc; and, c) in Computing Networks different games can be designed using different devices, such as modems, routers, firewalls, etc., as puzzle pieces.

For instance, a teacher of a Computer Architecture course may design an activity using a puzzle-based game compliant with the presented model. First of all, this teacher selects an inquiry-based learning approach to define de activity’s workflow (i.e. macro-scaffolding). The sequence of activities for an inquiry-based learning approach is: a) ask a question; b) research about the topic of the question; c) create a solution; d) discuss your solution; and e) reflect upon the activity. In this way, the teacher can define the question that the game will show to the students (see figure 3.a), defines the sources that the students would need to research about this topic (see figure 3.b), and then designs the elements the students would need in order to create their own solutions (see Figure 3.c).

The puzzle-based game’s interface will allow the students to drag and drop the elements from the list to a “construction” area where the students will build their own solutions (Figure 3.d).

Each element has its own hint (i.e. micro-scaffolding) describing their main functionalities, and each time a students makes a mistake when matching the elements, a hint (i.e. micro-scaffolding) would appear to students to guide them to a correct solution. Those hints would be previously defined by the teacher as well.

IV. CONCLUSIONS AND FUTURE WORK

In this paper we have described the potential benefits of using serious games in current education since they are more in correspondence to students’ interests. We have also highlighted the importance of scaffolding the learning process and the lack of devoted tools implementing such mechanisms of support.

Taking this situation in consideration, we have proposed a conceptual model for the design of puzzle-based games that provides scaffolding to students for performing different tasks. In particular, we described this conceptual model through the use of an aggregation model representing the relationships of the different components of the model, and a structure model emphasizing the functional relationships between these components.

Different learning situations in the area of ICT engineering education have been exposed. From these examples we stress that the use of puzzle-based games defined by this proposed conceptual model could increase the students’ interests and motivation towards the ICT field.

Different lines of future work emerge from the conceptual model presented in this paper and have to do with: a) the implementation of the conceptual model to allow teachers automatically create their own puzzle-based games; and b) the implementation and evaluation of puzzle-based games according to the principles of this conceptual model to analyse the learning benefits of using such approaches.

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REFERENCES


