NUCLEO an adaptive role game based scenario

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Abstract

University educational techniques are often anchored in traditional formats and instructional methods, causing an increasing lack of effectiveness, mainly because student's lack of motivation. Today students have grown up in an environment that dramatically differs from those of previous generations in the use of ubiquitous technologies. The NUCLEO e-learning system tries to approach the learning scenario to the engaging and immersive formats of the videogames. Conceived for teaching software programming disciplines, it provides a futurist scenario in which students (represented by avatars) have to collaborate to solve a learning "mission". The proposal is based in two socio-constructivist approaches, problem based learning and computer supported collaborative learning. A collaboration script, modelled with IMS LD, has been specifically designed to structure students' interaction for the domain knowledge. The system also makes use of adaptation techniques, based on modelling students' learning styles, to optimize group effectiveness and to individualize the educational strategy.

Keywords

Game based learning, adaptive learning, collaborative learning, problem based learning, e-learning standards

1 Introduction

The Net Generation [Tapscott 1998] has already arrived to university and college. They have grown up using technology for almost any activity; entertainment, studies, work, or communication happen through devices like computers, mobile phones or video consoles. This has surely affected the way they perceive and interact with the environment, both physically and socially. For instance, it is very difficult for these students to concentrate on a text for a long time because they are used to look for precise pieces of information in the web while, maybe at the same time, asking for help to friends with some instant messaging program. In this context, most university instructional methods, anchored in traditional text based formats, suffer from an increasing lack of student's interest. The educational community is starting to feel that the learning applications may benefit by taking some of the engaging features of videogames and Internet tools like: the active, the multitasking, the random-access, the graphics, the peer and group connected, the fun, the fantasy, and the quick feedback [Prensky 2001].

NUCLEO is an e-learning environment, conceived for teaching programming disciplines, that combines active and collaborative learning with the engaging formats of videogames and virtual worlds. Deeply grounded in the socio-constructive pedagogical stream [Vygotsky 1978], takes the learner (represented by an avatar) into a futurist scenario where he is supposed to solve a difficult mission working in collaboration with other students inside a team.

In this context, knowledge is assumed to be gained during the following processes:

- Problem solving procedures. The missions the students are proposed are complex programming cases presented in a format that respects the metaphor's videogame style and that is rendered in a virtual scenario.
- Collaboration procedures. The missions are conceived to be solved in collaboration inside a team specifically formed for that purpose.

Therefore, the system combines the problem based learning (PBL) and the computer supported collaborative learning (CSCL) approaches in a framework that uses a multiplayer role videogame as the delivery format.

Modern videogames have several interesting features that may be used for educational purposes; they are immersive, they give the player the power to drive the game experience, they provide a safe environment with a very tight feedback loop where trial and error is encouraged and they foster competition and collaboration. Further, multiplayer games may motivate through independent roles and the social bonds that are formed between players. While there are communities of practice formed around stand-alone games, some argue that there is an even stronger foundation underlying multiplayer games [Sellers 2002]. Thus, it makes sense the idea that multiplayer videogames may be a natural medium for sustaining this sort of self regulated communities where learning takes place by actively participating in the social activities and events of the community [Lave, Wenger 1991].

Nevertheless, relying education uniquely in this sort of spontaneous free interaction may not be a suitable option for most university disciplines, especially for those in which the learning domain is constricted by a predefined program and a fixed time period (usually a semester). On the other hand, research shows that when learners are left to their own devices, they rarely engage in educationally relevant activities as asking each other questions, explaining and justifying their opinions, articulating their reasoning, or elaborating and reflecting upon their knowledge [Kobbe 2005]. In the field of CSCL collaboration scripts aim at structuring collaborative learning processes in order to trigger group interactions that rarely take place in free collaboration [Dillenbourg, Tchounikine 2007]. Scripts are designed to support collaboration among learners by defining sequences of activities, by creating roles within groups and by constraining the mode of interaction among peers or between groups. Like other researchers [Miao, Harrer, Hoeksema, Hoppe 2007] we are interested in representing collaboration scripts in a formal way so that they can be interpreted by a computer. Currently in most CSCL tools scripts are embedded or encoded in the environment. Expressing scripts using a modelling language would also permit separating their logic from their presentation. In NUCLEO we use for this purpose an extension IMS LD [IMS Global Consortium 2005], the de facto standard language for pedagogical modelling within the learning community. The extension implements some of the suggestions identified for collaborative learning in several recent works [Caerio, Anido, Llamas 2003; Hernández, Asensio, Dimitriadis 2004; Miao, Harrer, Hoeksema, Hoppe 2007] in order to address the system specific needs.

Another issue that deeply affects the results of the learning experience in collaborative learning is the way in which students are grouped. A positive learning experience might turn into a negative one depending on the group composition [Alfonseca, Carro, Martín, Ortigosa, Paredes 2006]. NUCLEO makes use of adaptation techniques to optimize student's interaction by forming groups in which members' learning strategies are compatible. We use for this purpose a simplified framework of Vermunt's model of learning styles [Vermunt 1992] that helps us to distinguish the students that need more intensive guidance through the learning process from those who are more capable of driving their own learning experience. By grouping students according to their learning habits, the teacher's task overload may also decrease because part of his job in leading and guiding the group will be presumably assumed by the most capable students. The adaptation model in NUCLEO is also in charge of providing personalized learning activities to the students in order to address their specific learning needs.

The remaining of this paper is structured as follows: in section 2 the pedagogical foundation underneath NUCLEO system is briefly described; the architecture of the systems is outlined in section 3, and the in the following subsections the main features of the system components are presented; in section 4 some conclusions and future work are discussed.

2 Pedagogical Assumptions

As already stated in the introduction, the system presented in this paper combines two instructional approaches that belong to the socio-constructive stream of learning, problem based learning and collaborative learning, in a virtual learning environment that places the scene in role game play.

All the approaches in the socio-constructivist tradition share the consideration that learning happens through the participation in social activities where the student establishes a complex interaction with his environment. Particularly PBL and CSCL are increasingly popular instructional methods that require learners to actively gather and apply knowledge in order to solve ill-structured real-world problems. The principles embodied in these approaches require from both the learner and the teacher to develop different abilities than the ones required in traditional educational settings. The learner has to actively interact with the learning material, to collaborate with other students and to be involved in self and peer assessment. The teacher, instead of supplying direct information to students, takes the role of facilitator, encouraging students, giving hints and providing feed-back.

PBL is an instructional approach that exemplifies authentic learning and emphasizes solving problems in rich contexts individually or in groups. When the instructional method explicitly requires collaboration procedures to come to a solution, PBL becomes problem based collaborative learning. If the interaction among co-learners takes place using computer networks to enhance the learning environment, it is called computer supported collaborative learning (CSCL). CSCL is an interdisciplinary field of research "focused on how technology can facilitate the sharing and creation of knowledge and expertise through peer interaction and group learning processes" [Resta, Laferrière 2007]. Educational literature has demonstrated the benefits of PBL and CSCL to enhance student's thinking skills [Boud, Fellette 1991]. However research has also shown that the implementation of these approaches is a challenging and complex task for both teachers and students. Some of the reasons are [Miao, Holst, Haake, Steinmetz 2000]: Teachers and learners who are unfamiliar with these approaches tend to be reluctant to change their traditional roles; Students easily loose focus and get frustrated by lack of adequate guidance and help, this implies that effective PBL requires the tutor to provide a lot of personal attention to the students which is sometimes difficult in the current academic context [Suebnukarn, Haddaway 2006]; It is hard to keep track of progress and assessment of the learning goals; Group interactions weaken and fail in providing fruitful collaboration in lack of the adequate channels and protocols of communication. The NUCLEO e-learning environment aims to address these difficulties by means of two software constructions: collaboration scripts to structure students' interaction, and an adaptation model designed with a two fold objective, to improve student grouping and to provide specific learning activities to those students that need to cover a specific learning gap.

Collaboration scripts aim at representing how learners and tutors are expected to behave during the learning process, restricting and defining the behaviours allowed. A collaboration script divides the learning process into different phases over time which can be sequentially ordered or networked. Each participant of the learning process is assigned to a role, which specifies who is permitted to perform which operation on which type of object within that phase [Miao, Holst, Haake, Steinmetz 2000]. Within the literature of software engineering it is clear that the waterfall model for software development (the domain for which our tool is conceived) is well structured and can be divided into a number of distinct phases (analysis, design, coding, testing, implementation and maintenance). Our idea is to use scripts to structure student's behaviour both through and inside these phases (macro and micro script). The macro script is conducted by the transition through specific multimodal interfaces (see Figure xxxx), that typically end with the production of a predefined artifact (a document, a design or code implementation) that will be assessed by the teacher. At the micro scripting level, our intention is to respect as much as

possible free interaction among students, however the role they play in the virtual scenario conditions their privileges and triggers some individual learning activities.

On the other hand, adaptation is a central subject in e-learning. It can be characterized as the ability of an e-learning system to adapt to different conditions over time. In general, the adaptation process can be described by three stages: retrieving information about the user, processing the information to initialize and update a user model, and using the model to provide the adaptive behaviour [Brusilovsky, Maybury, 2002]. Among the aspects about the users that are more commonly considered in existing user models are students' previous knowledge, goals, preferences, etc. One of the students' features that can be part of the user model is their learning style. Vermunt defines learning style as "a coherent whole of learning activities that students usually employ, their learning orientation and their mental model of learning". He classifies students into five types depending on the attitudes they adopt in five different areas of learning (the resulting 4x4 matrix is shown in Table 1). We believe this a useful classification in order to identify how capable is a student of driving his own learning process and how much of teacher guiding he needs. Our idea is to form groups in which student's learning strategies are compatible. An implicit assumption in collaborative learning is that students working in groups will learn from and teach one another, therefore students whose cognitive abilities are more developed (MD and AD styles) can help and guide the rest (U and RD). In NUCLEO the role the student plays in the learning scenario is determined by his learning style that conditions his duties in the proposed mission as well as the tools he is allowed to use (by means of the script). Along with the common mission, individual learning activities may also be proposed to the student depending on his role in order to address specific learning needs of his learning style type. This way the adaptation model helps making tutor task a little less demanding by distributing part of his role to the technology and to the students themselves.

	Meaning-directed (MD)	**Application-directed (AD)**	**Reproduction-directed (RD)**	**Undirected (U)**
Cognitive processing	Look for relationships between key concepts/theories: build an overview	Relate topics to everyday experience: look for concrete examples and uses	Select main points to retain	Find study difficult: read and re-read
Learning orientation	Self-improvement and enrichment	Vocational or "real world" outcomes	Prove competency by getting good marks	Ambivalent; insecure
Mental model of learning	Dialogue with experts stimulates thinking and engagement with subject through exchange of views	Learn in order to use knowledge	Look for structure in teaching and texts to help take in knowledge and pass examinations. Do not value critical processing or peer discussion.	Want teachers to do more. Seek peer support
Regulation of learning	Self-guided by interest and their own questions; diagnose and correct poor understanding	Think of problems and examples to test understanding, especially of abstract concepts	Use objectives to check understanding; self-test; rehearse	Not adaptive

Table 1: learning styles types in Vermunt framework

3 System Description

In the metaphor we have created, "NUCLEO" is an artificial world populated by a special kind of living beings in the form of Artificial Intelligences (AIs). The NUCLEO civilization is

threatened to extinction by a mysterious virus capable to destroy entire virtual worlds. The AIs superior council, formed by the most wise and oldest AIs (this is the role assigned to the tutor), decides to call beings from the three most important tribes of the NUCLEO to combat this terrible menace. The “evians”, a tribe that inhabits the metropolis of the NUCLEO, formed by specially qualified AIs. This is the role associated to the MD and AD learning styles (we are currently using a simplified model that merges MD and AD into one style). The “ruks”, an itinerant tribe in the peripheral regions of NUCLEO, they are pirates and mercenaries. This is the role for the RD learning style type. And the “exters”, strange and unpredictable AIs that have evolved in extreme conditions, they are mutants, odd being forms with strange powers difficult to control. This is the role assigned to the U students. In this context, students' avatars have to collaborate in order to accomplish a proposed mission (which represents a certain learning objective) following a classical role based playing mechanics.

The system architecture is divided into three main components that are outlined in Figure 1: the learning strategies manager, the adaptation engine and the player.

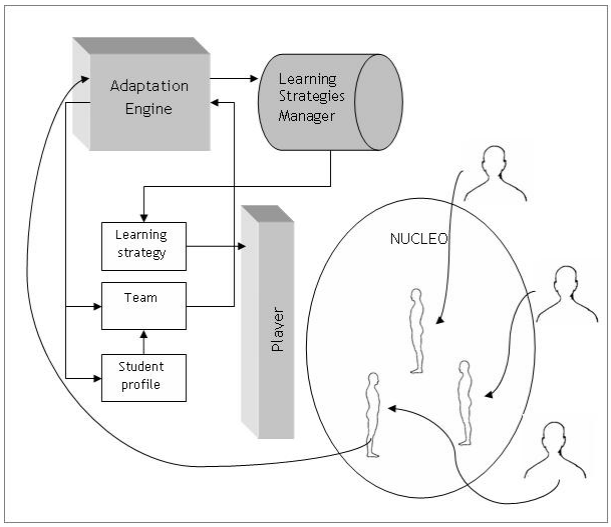

Figure 1. System Architecture

3.1 The Learning Strategies Manager

This part is in charge of the creation, storage and management of the personalized learning strategies and all their components (phases, roles, activities, environments, tools and learning objects). The learning strategies are structured by collaboration scripts and are expressed in a computational form by using an adaptation of IMS LD specifically conceived to cover collaboration requirements. A learning strategy is codified in a UoL and represents a two fold objective: to gain the corresponding domain knowledge and to promote MD and AD learning patterns. It follows the structure outlined in Figure 1: it includes a collaborative mission and some individual challenges (learning activities to be performed by certain roles). In this schema, the roles are constructions that condition student's participation in the collaborative process (represented by the common mission) as well as the individual activities he is proposed.

3.2 The adaptation engine

It is in charge of creating and maintaining the student's model based on which students' groups are formed and personal learning activities are triggered. In our case, and for the scope of this work, the user model refers only to the student's learning style. So the student's learning style is the determinant of the adaptation process (i.e the aspect of the learning experience which drives the adaptation or "on what is the adaptation based") and the constituents (i.e. the aspects of the

learning experience subject to adaptation or "what is being adapted") are teams and the learning strategies [Brusilovsky, 1999].

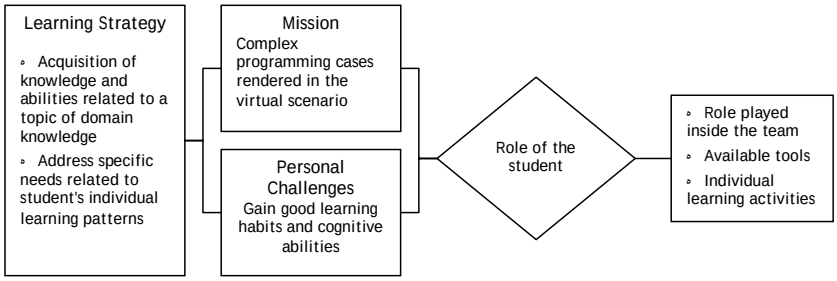

Figure 1. Structure of a learning strategy

Among the variety of proposals for user modelling [Brusilovsky, Millán 2001], in "NUCLEO" we use a dynamic stereotyping model that responds to the following adaptive cycle: At the first step (*pre-test)* the system classifies the student into a certain learning profile by gathering the information required using a simplified version of the "Inventory of Learning Styles". Once the student has been profiled, the adaptation engine has to update and maintain this profile. For that purpose we use two different strategies: assess the results achieved by the learners in the individual activities (used to evaluate the accurateness of individual profiles) and asses the results of the collective activities (used to evaluate group compatibility).

Adaptation of the learning strategy is supported by associating instances of the element role provided in the IMS LD specification to the different student profiles. According to the specification, there are two basic roles that take part in a learning process: student and staff (tutors and course designers). But [Koper, Olivier 2004] recognizes the need of extending the specification "to include the multi-role interactions and the various pedagogical models that are needed to provide real support for learners and teachers in more advanced and newly developing educational practices". As the different learning activities are conceived to be performed by a certain role, we can create one role for every defined learner profile (in our case for the considered learning style types). By this mechanism certain activities in a defined UoL will be only performed by certain roles (profiles).

3.3 The Player

A Learning Design Player is a tool capable to open a UoL and provide the participants with an appropriate interface to perform the required activities during the learning process. A UoL encapsulates all the information required to perform the teaching and learning process; the activities to be done, who is supposed to do them, and in what sequence they have to be completed. These activities can refer to different learning objects (e.g. books, articles, software programs, pictures, and games) and services (e.g. forums, chats, and wikis) that are used to collaborate and to communicate in the teaching-learning process [Koper 2006]. Thus, the player is in charge of the following duties: Interpret and set up learning design files; Provide a user interface; Integrate all the services that are referred to in the Learning Design; Create a run of the Unit of Learning; Assign the persons to the correct roles; Connect to external systems. In addition to all these features, which are common to every learning design player, the NUCLEO player has to be enhanced to provide support for learner's virtual representations (i.e. avatars) and a graphical interface that recreates the futurist scenario where the metaphor is livened up (see Figure 3).

4 Conclusions and Future Work

Our research team is concerned about finding e-learning solutions to improve our student's performance at the Complutense University of Madrid [Fernández-Manjón, Sancho, 2002; 2007; Moreno-Ger, Sancho, Martínez-Ortiz, Sierra, Fernández-Manjón, 2002; Sancho,

Fernández-Manjón, 2005]. The approach presented in this paper, belongs to the socio-constructivist pedagogical stream and it implements an adaptation model based on his learning style type in order to improve grouping and individualize instruction. For that purpose, we have created a futurist metaphor implemented as a role play game in which students have to collaborate to solve a proposed mission which stands for a certain learning objective. Learning strategies (including collaboration scripts) are modelled with IMS LD. We believe this type of pedagogical approach can succeed in making contents more engaging and motivating for students and that it may improve their learning performance globally; first by optimizing the knowledge acquisition, and second by helping the student to acquire better learning habits. In order to prove our hypothesis, a pilot system will be used for teaching a programming course in C++ next semester at the Physics Faculty of the Universidad Complutense de Madrid in Spain.

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