Do Multi-User Virtual Environments Really Enhance Student's Motivation in Engineering Education?

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***Abstract* – The use of Multi-User Virtual Environments (MUVEs) in education is increasing mainly due to motivational aspects. However, more practical research about the impact of MUVEs on students' motivation in real educational contexts is required. Here we present *Mare Monstrum*, a system which integrates a MUVE with a Learning Management System and uses a fantastic narrative metaphor for teaching programming. The impact of the theories implemented in *Mare Monstrum* on the students' motivation have been evaluated in several case studies in the Spanish higher education context. In this paper we describe the system, the underlying hypotheses we intend to prove, the case studies and, finally, we present a brief discussion on the results obtained.**

Index Terms – Computer Supported Collaborative Learning, Game Based Learning, and Learning in Multi-User Virtual Environments.

INTRODUCTION

Multi-User Virtual Environments (MUVEs) have become a hot topic in e-learning trends. A proof of this claim is the numerous educational uses that some general-purpose MUVEs are being given (e.g. *SecondLife*™ [1][2]). Moreover, many virtual worlds have recently been specifically developed for education, supporting young people in learning a wide domain of subjects. Some of the most cited examples are *River City* [3], *Revolution* [4], *AquaMoose* [5] or *Quest Atlantis* [6]. Finally, a growing body of research reveals the educational and social potential of virtual worlds [7][8].

Probably this increasing interest derives from the hypotheses proposed by a group of researches [9] according to which traditional textual learning contents do not capture the attention of *digital natives*. This generation of youngsters is used to multi-media applications that are, above all, immersive and highly interactive. Technology in general and videogames in particular, with their appealing graphical interfaces, have been part of their everyday lives since they were kids. Therefore the formats of educational applications must be adapted to what the *digital natives* feel more attracted to.

The fact is that, in the last decade, educational applications have suffered a deep transformation, from computer-assisted instruction (CAI) and intelligent tutors to the use of Massive Multiplayer Online Games (MMOG) (e.g *the World of Warcraft*) for educational purposes. But, the question is: are these applications really effective in terms of motivation enhancement? Moreover, are they more effective for reaching specific learning objectives than traditional approaches? So far, these questions cannot be answered, partly because more practical research in this field is needed. Even though some experiments have been performed in this concern [10], they are still insufficient to reach a solid conclusion.

Mare Monstrum is an e-learning application developed following the theories of the NUCLEO project. The NUCLEO research project was conceived for teaching software programming modules within a blended learning frame. NUCLEO relies both on a MUVE as user interface and a fantastic narrative metaphor of the lesson to enhance the motivation of the students. Besides, NUCLEO pursues three main objectives: (1) to improve students' motivation as a way to reduce the alarming growth of dropout rates, (2) to move students' towards a more active role in learning, and (3) to help the students to develop teamwork abilities and soft skills at the same time they acquire the state-of-the-art knowledge and technical skills.

In order to accomplish these objectives, NUCLEO uses a Problem Based Learning (PBL) approach as the underlying pedagogical strategy, where the learning scenario is set in a fantastic virtual world of role games (see [11] for further details about the NUCLEO project).

Mare Monstrum is a prototype developed to test some of the hypotheses described in NUCLEO. To be more specific, *Mare Monstrum* analyzes those issues related to the use of the MUVE as user interface and the game elements (including the avatars and the graphical tools) as the means to increase motivation. Thus, a 3D immersive scenario is used to implement a game narrative that includes role play dynamics and fantasy. Also to enhance the competition atmosphere social recognition strategies are used. *Mare Monstrum* integrates two existing platforms (Moodle [12]

and Multiverse [13]) to achieve the three aforementioned goals. It has been evaluated through two cases of study: one with actual university students and the other with a group of experts and selected users. In this paper we present the results obtained in the evaluation of the *Mare Monstrum* system.

The paper is structured as follows: Firstly, we briefly describe the NUCLEO theoretical framework, followed by a description of the *Mare Monstrum* system. Next, we present the two cases of study that have been performed to test the underlying hypothesis. In the next section we discuss on the results obtained. Finally, some conclusions and future work are presented.

NUCLEO: A BRIDGE BETWEEN MUVES AND E-LEARNING SYSTEMS

The use of digital games and MUVEs as educational tools has drawn significant attention [7]. Digital games engage users with challenges that take place inside immersive narratives using realistic artificial scenarios, where students can formulate hypothesis and test them in the virtual world. Hence digital games are an ideal channel to promote relevant educational aspects such as problem-solving skills or analysis and reflection.

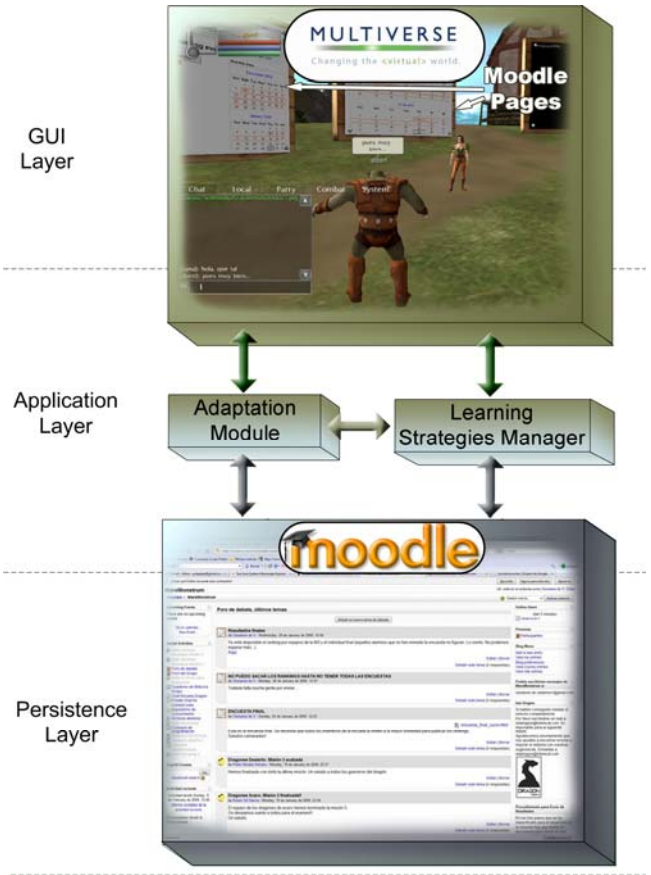

FIGURE 1
REFERENCE ARCHITECTURE BEHIND THE NUCLEO FRAMEWORK

Nevertheless, as recent research reveals [14] most of the educational gaming approaches present a lack of balance between educational value and fun, which is the game essence.

Also, the use of digital games and MUVEs has some drawbacks that have not been totally addressed yet. For instance, digital games and MUVEs are rarely fully integrated in the educational infrastructure and behave as "black boxes". Thus it is impossible to get any instructionally relevant information about the course of the game-based learning experience, such as students' performance for assessment or keep a persistent student historical record.

These issues could be addressed by taking advantage of the already deployed e-learning infrastructure. Many educational organizations are using modern Virtual Learning Environments (also called Learning Management Systems or LMS) not only for distance learning but also as a complement for traditional lectures (an educational trend usually known as blended learning or b-learning). Those LMS (e.g. Moodle, Blackboard-WebCT, Sakai, etc.) are not only content repositories, but rich web-based systems, that provide instructors with tools to track and evaluate the performance of the students, keep a record of each student or to promote communication and collaboration between students (i.e. collaborative learning). Thus a synergy between educational gaming and e-learning could bring together the benefits of both worlds.

This is precisely the point where the NUCLEO project aims to contribute. NUCLEO is an instructional framework that integrates a 3D MUVE with an LMS (Figure 1 shows the reference architecture), using a pedagogical approach deeply grounded in the socio-constructive stream, in which students collaborate in small teams to reach the solution of real-world, open-ended, ill-structured problems as they would do in classical problem based learning scenarios [15]. The difference is that the real course is represented metaphorically by a fantastic virtual world. Therefore in NUCLEO, instead of trying to sugar coat the educational content as fun (as most game based learning approaches do), it turns the whole learning scenario into a game. On the other hand, NUCLEO is conceived to be used as a plug-in application over an LMS, therefore, services, tools and data are managed in a centralized way at the same time that simplifies its integration in the educational infrastructure.

DESCRIPTION OF THE PROTOTYPE MARE MONSTRUM

Mare Monstrum is a system developed following the theories of the NUCLEO framework. In *Mare Monstrum* learning takes place in a fantastic world, the Dragon Island, inhabited by the survivors of an ancient civilization, the Picts. They are menaced by a terrible enemy, the Dark Lords, who want to destroy all the knowledge and plunge their world into darkness. The Sea Dragons, the last guardians of wisdom, take the responsibility to train the Picts in the weapons of knowledge. Within this metaphoric

frame the game simulates a school of warriors competing to get the grade of Dragon Warriors. Students play the role of these candidate champions through an avatar, while tutors play the role of the Sea Dragons.

In *Mare Monstrum*, social interaction takes place according to two different schemas (competition and collaboration) and at two different levels (individually and in groups). Competition and collaboration are two of the foundations of both NUCLEO and *Mare Monstrum*, as they are two of the team making mechanics that have proved to boost motivation and to improve group dynamics in different learning contexts [16].

Mare Monstrum supports these mechanics with two main resources. Firstly, it promotes social recognition through rankings and rewarding students' avatars with physical distinctive characteristics according to the students' achievements. Secondly, it addresses the different levels and schemas of social interaction dividing the virtual world of *Mare Monstrum* in three different zones, with specific tools to facilitate the interaction (see Figure 2):

- *The Pict Village: area for global interaction*. Information panels, such as the mission announcements panel, the individual and the group rankings, and the public forum are displayed here. These panels are directly connected to the LMS (i.e. Moodle), and reflect automatically in the MUVE any change on the persistent record that the LMS stores. All the students have access to this zone, but they only can access the information related to the course they are registered in. The course rankings are public to all its members to foster motivation by social recognition (see Figure 2).
- *The boats in the Pier: area for group interaction*. A boat in the sea represents a restricted group interaction zone. It is fit out with tools to manage group collaboration, such as private forums, blogs or file sharing facilities (see Figure 2).

The Dragon Cliffs: area for student-tutor interaction. There are two types of facilities at this zone: a zone to send messages to the teacher and a zone in which the tutor can leave additional files for the students (see Figure 2). To force in-game team communication between students only some of them are allowed to communicate to the teacher.

FIGURE 2
FOUR DIFFERENT SCREENSHOTS CORRESPONDING TO THE FOUR DIFFERENT AREAS OF MARE MONSTRUM: PICT VILLAGE (A), PIER (B), DRAGON CLIFFS (C) AND INSIDE OF A BOAT (D).

TWO CASES OF STUDY OF APPLYING MARE MONSTRUM TO ENGINEERING EDUCATION

So far, *Mare Monstrum* has been evaluated through two different case studies. In the first case study *Mare Monstrum* was used in a real educational context. In the second case study *Mare Monstrum* was tested by a group of experts and selected users (both teachers and students).

The case studies were designed to evaluate how the next three elements of *Mare Nostrum* affect motivation:

- The role game dynamic of the learning scenario
- The immersive 3D MUVE scenario
- The fostering of competition by using social recognition strategies.

I. First case study: Teaching "Programming Fundamentals" to Electronic Engineering Students.

"Programming Fundamentals" (PF) is an optional module of a five-year degree of the Electrical Engineering School at University Complutense of Madrid. The module aims to teach programming basics, such as algorithms, program design and coding.

Over the last few years, lecturers had observed that dropout rates have alarmingly increased and the grades of the students are going gradually lower. Within the period from 2005 to 2007 (i.e. two academic years), the lecturers of the module followed a traditional teacher-centered approach that included lectures, practical laboratory sessions and a compulsory exam as evaluation method. For calculating the students' final grades, lecturers took into account the marks obtained in the practical sessions and the final exam.

The next year (2007-08) a preliminary prototype of the NUCLEO framework (*Mundo Nucleo*), similar to *Mare Monstrum* but which used a simple 2D GUI instead of a 3D immersive world, was used by a group of volunteers (27 over a group of 60) obtaining very promising results (see [17]). In 2008-09 the complete prototype *Mare Monstrum* was used by all the 54 students enrolled in the course.

Table 1 and Figure 3 show the evolution of the drop out rates throughout the period 2005-09.

TABLE I
STATISTICAL DATA FOR DROPOUT RATES FOR THE 2005-09 PERIOD.

Academic year	Pedagogical approach	Students enrolled	Students attending the exam	Dropout rate (%)
2005-06	Traditional	115	43	62.61
2006-07	Traditional	110	33	70
2007-08	Traditional	38	13	65.8
	NUCLEO (Mundo Nucleo)	22	20	9.09
2008-09	NUCLEO (Mare Monstrum)	54	45	16

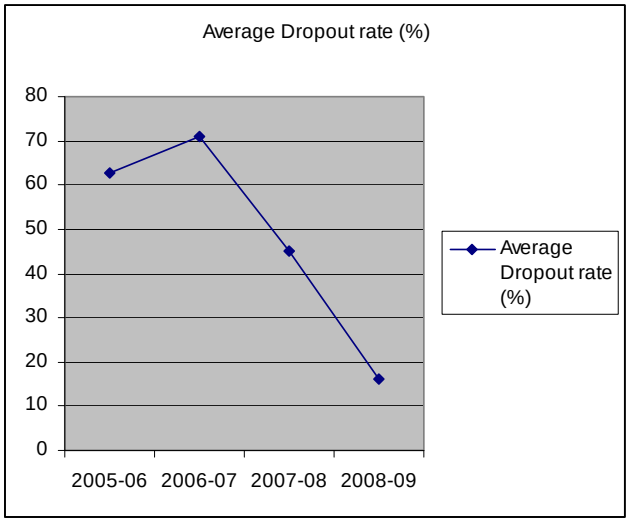

FIGURE 3
EVOLUTION OF THE DROPOUT RATES THROUGH 2005-2009 PERIOD.

In addition, in 2008-09 students filled a satisfaction questionnaire to collect their opinion over different issues related to the system. Three questions are relevant to this paper:

- "In your opinion, has the 3D virtual world GUI affected your motivation?"
- "Did the role game dynamics have any impact on your motivation towards the module?"
- "Has the competitive atmosphere been positive for your motivation?"

Figure 4 shows the percentages of students that agreed or disagreed to these questions.

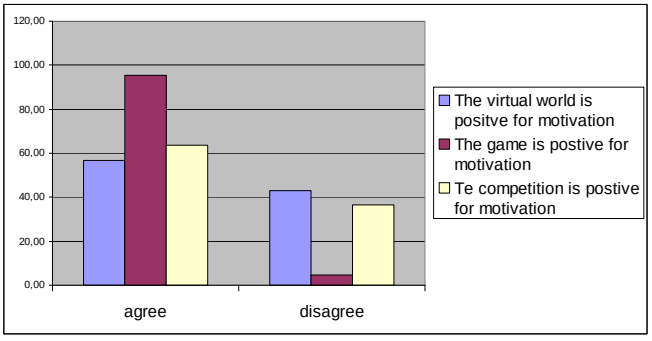

FIGURE 4
RATES OF THE STUDENTS IN AGREEMENT OR DISAGREEMENT WITH THE PROPOSED QUESTIONS FOR THE FIRST CASE STUDY.

II. Second Case Study: Evaluation of Selected Users and Experts.

In the second case study consisted the system was evaluated by 24 experts and selected users (eight teachers and sixteen selected students). All the selected teachers were experts in the design and development of e-learning applications and

taught modules of computer programming. All the selected students declared to be fond of playing digital games or Massive Multiplayer Online Role Games (MMORG). Both groups (teachers and students) filled a satisfaction questionnaire after trying the system out for several days.

The questions were quite similar to case study 1 and the results obtained are depicted in Figure 5 and Figure 6. Additionally, for this case study we also sought to measure the usability of the different collaborative tools included in the environment (results are depicted in Table 2).

TABLE 2
RESULTS OBTAINED FOR THE EVALUATION OF THE DIFFERENT TOOLS AND SERVICES OF THE ENVIRONMENT

Type of tool	Educational role	Agree (%)	Disagree (%)
Using the LMS as backend application	Student	92,85	7,14
	Teacher	100	0
Course forum	Student	92,85	7,14
	Teacher	100	0
Chat	Student	57,14	42,85
	Teacher	100	0
Public informative panels	Student	92,85	7,14
	Teacher	100	0
Tools for communicating with the tutor (dragon cliff)	Student	100	0
	Teacher	100	0
Private tools for group working	Student	92,85	7,14
	Teacher	100	0

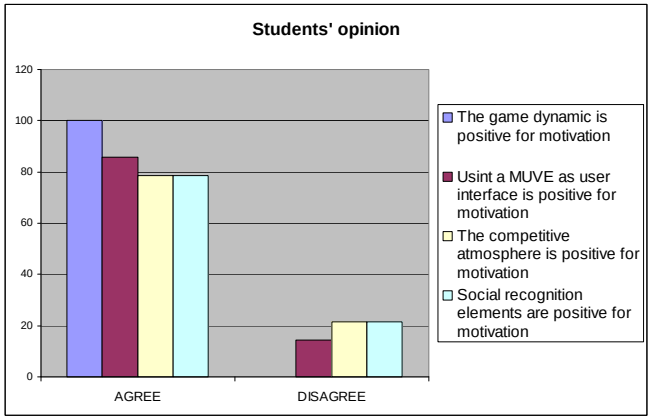

FIGURE 5
RATES OF THE STUDENTS IN AGREEMENT OR DISAGREEMENT WITH THE PROPOSED QUESTIONS FOR THE SECOND CASE STUDY.

DISCUSSION OF THE RESULTS

In the first case study the analysis of the evolution of dropout rates during the 2005-2009 period shows that when a traditional teacher-centered approach was followed, the dropout rates average was around 65%. These rates compare the students that attended the final exam with the students enrolled in the course. In 2007-08, the first prototype (which used a 2D GUI instead of a 3D virtual world) was used by a group of 22 volunteers. While the control group maintained a similar dropout rate, the experimental group reduced the dropout rate from 65% to 9.09%. These results could be influenced by the voluntary nature of the experiment, which could have attracted highly-motivated students. Nevertheless, in 2008-09 the use of *Mare Monstrum* was compulsory for all the students and the dropout rate at the end of the course was 16%. Although this rate is slightly higher than the previous year, it is still a great improvement.

Besides, according to the impression questionnaire, 95.45% of the students thought that the role game dynamics has made the course more motivational and fun. Regarding the using the use of a MUVE as user interface to immerse the learning scenario in a fantastic world, only a slight majority (56.82%) considered that it was positive for the motivation. Finally, boosting competition using social recognition strategies was motivating for 63.64% of the students. The conclusion is that the most powerful aspect for motivation is the use of game mechanics in the learning experience, independently of how the game is presented to the students (using a 3D virtual world interface of a 2D GUI).

In the second case study the results of the satisfaction questionnaire (the only metric used) were separated in two different groups for analysis: the teachers and the students. The results support all the conclusions of the first case study but one. All the teachers agree in that the MUVE interface is positive for students' motivation, while in this case, the students that think that the MUVE is a positive element in terms of motivation rises up to 85.71%. This difference may be related to the fact that those students were frequent users of MMORGs.

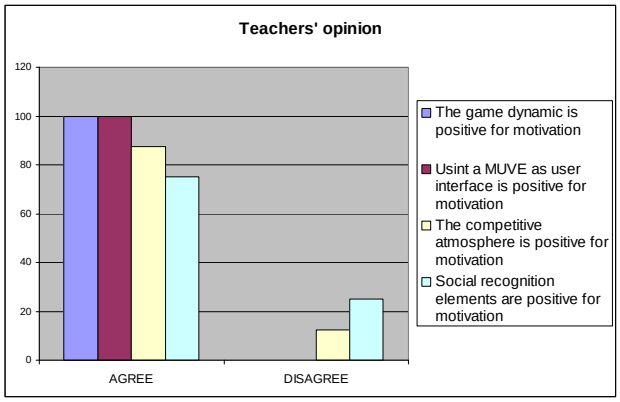

FIGURE 6
RATES OF THE TEACHERS' IN AGREEMENT OR DISAGREEMENT WITH THE PROPOSED QUESTIONS FOR THE SECOND CASE STUDY.

In this second case study is also remarkable that while, in general terms, all the tools available in the environment for educational purposes have been evaluated as useful or very useful, it seems that students consider the chat (both voice and text) the less useful tool. This was shocking for the evaluators, as we have checked that this was the tool most frequently used in the environment. In our opinion, this could be due to the reason that the students used the chat mostly for non educational but for socializing purposes.

CONCLUSIONS AND FUTURE WORK

In this paper we have presented the results obtained in two case studies aimed at evaluating a set of hypotheses related to how three different strategies used in the NUCLEO framework affect students' motivation. The evaluation has been performed using *Mare Monstrum* which was developed specifically for this purpose.

Even though this evaluation is just a starting point, and more practical research has to be performed in order to establish final conclusions, taking as a base the results obtained in our experiments, we can extract the following conclusions:

- Fantasy and gaming are powerful motivators. But representing them in immersive 3D multi user interface, with powerful graphics, does not seem to be as important as the gaming or the learning strategies themselves.
- Boosting competition using social recognition strategies, works very well for the majority of students while it is counterproductive for a small minority.

Next steps in the project are to obtain a more complete MUVE, easier to install, with improved teacher support and to extend its usability for other knowledge domains different from programming courses.

ACKNOWLEDGMENT

The Spanish Committee of Science and Technology (projects Flexo-TSI-020301-2008-19 and TIN2007-68125-C02-01) has partially supported this work, as well as the Complutense University of Madrid (research group 921340) and the EU Alfa project CID (II-0511-A).

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