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3D SIMULATION AS A LEARNING ENVIRONMENT FOR ACQUIRING THE SKILL OF SELF-MANAGEMENT: AN EXPERIENCE INVOLVING SPANISH UNIVERSITY STUDENTS OF EDUCATION*

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ABSTRACT

In this study we analyze how 57 Spanish university students of Education developed a learning process in a virtual world by conducting activities that involved the skill of self-management. The learning experience comprised a serious game designed in a 3D simulation environment. Descriptive statistics and non-parametric tests were used in the analytical process. An analytical rubric was taken as a reference to enable an expert observer to collect the relevant information. Our results show that the students generally achieved good levels of self-management in this technological environment. Senior university students presented higher scores than freshmen in this particular skill. We also found that students tended to develop better learning activities that involved analytical work than those that involved action or development. The

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students' perceptions about 3D environments regarding self-management were mostly satisfactory, especially for planning activities. These results provide relevant information on how students develop activities that involve self-management components in a technological environment. However, the research design did not allow us to determine how this environment increases the level of this specific skill.

INTRODUCTION

In the last two decades the development of Information and Communication Technology (ICT) has brought with it significant educational implications. Increasingly, knowledge is "decentralized," teachers are losing their misgivings towards technology, and learning environments are becoming ICT spaces that are interdisciplinary, collaborative and virtual (Garcia et al., 2010; Johnson, Adams, & Cummins, 2012).

3D simulated virtual environments have considerable potential in education for training, experimentation and evaluation (Alrayes & Sutcliffe, 2011; Allen & Demchak, 2011) and can constitute an extraordinary didactic scenario in which students can act collaboratively (Gisbert, Cela-Ranilla, & Isus, 2010).

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Also in recent years, the term *skill* or *competence* has moved to a central position in university curricula. In Europe, curricula have been redefined in terms of competencies or skills, concepts that go further than specific contents.

These skills are requirements for the development of an individual and a social life in terms of success, responsibility, active citizenship, employment, and meeting present and future challenges in a modern, democratic society (European Communities, 2007).

In this paper we discuss one of these generic skills: self-management. Self-management is one of the most important skills for professionals in education (ANECA, 2005; UNESCO, 2008), which is the discipline to which the participants in this study belong.

In the literature on the topics discussed in this paper, it is difficult to find research that combines learning environments based on three dimensional (3D) technologies and the development of self-management. This makes it difficult to provide a basic argument for the forthcoming discussion but does not prevent us from presenting several ideas and conclusions as an exploratory view of the educational implications.

This study involves the following two components: technological simulations and self-management. Our definition of self-management is taken from the Spanish R+D project Simul@ (2011), which was developed at different levels of aggregation (dimensions and elements) and which defines the whole concept in an analytical manner.

The aim of the study is to describe how students put into practice activities that involve the skill of self-management within a technological environment; specifically, a 3D simulated learning environment. We observe whether differences in students' performances exist based on gender or academic level (senior or freshmen students). Additionally, we analyze the students' perceptions on using this technological environment in their experience of acquiring the mentioned skill.

Theoretical Background

Generic Skills: Self-Management

The rapid development of digital technologies in the digital era presents situations that require individuals to employ a growing assortment of cognitive skills in order to perform and solve problems in new environments (Aviram & Eshet-Alkalai, 2006).

Generic or transferable skills are understood as competences that are common to the majority of professions, contribute to valued outcomes for societies and individuals, and help individuals meet important demands in a wide range of contexts (OECD, 2005). One of these skills, which we analyze in this study, is self-management.

The enGauge 21st Century Skills (Burkhardt et al., 2003) defines self-direction as the ability to set goals for learning, plan for the achievement of those goals, independently manage time and effort, and independently assess the quality of learning and any products resulting from the learning experience. In 2005 the DeSeCo project (OECD, 2005) divided key competencies into three main categories. The first two categories concerned the use of tools and interaction in groups while the third category was more related to self-management. According to this third category, individuals need to be able to take responsibility for managing their own lives, situate their lives in the broader social context, and act autonomously.

The Partnership for 21st Century Skills (2011) defines self-management as a set of goals with tangible and intangible success criteria: balancing tactical and strategic goals; utilizing time and managing workload efficiently; and monitoring, defining, prioritizing and completing tasks without direct oversight.

For our present study, self-management involves acting strategically on a project, process or activity in order to anticipate which actions to take and make the right decisions during its development. In other words, project management means applying knowledge, skills, tools and techniques to the project activities in order to achieve the fixed objectives.

As we can see, these skills are complex artefacts that integrate multiple types of knowledge, abilities and attitudes. Their definitions need to be operationalized by describing their elements and learning objects in order to work and assess them according to their complexity (Prades, 2005; Simpson, 2003). In fact, this skill is described via four dimensions that provide an analytical rubric that has already been validated in a Spanish R+D project entitled Simul@ (http://late-dpedago.urv.cat/simula/). This rubric comprises: Planning (to anticipate actions for developing a systematic and efficient working process coherent with the defined aims); Organization (to develop a temporal sequence for tasks, assign responsibilities, and anticipate the resources needed when planning); Development (to implement and readjust the defined process); and Assessment (to identify, obtain and analyze information to guide decision making during the process, solve problems, and suggest improvements).

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To clarify our point, we analyze self-management as a transferable competence that must be acquired in order to perform both academically and professionally. To add an action component, we observe self-management in terms of the planning of activities to construct an artefact with a constant regulatory system.

3d Learning Environments

One technological perspective in ICT is 3D virtual environments for learning. Multi-user virtual environment (MUVE) technology exponentially ascending knowledge and communication possibilities provide immersive learning environments. M-learning, augmented reality and game-based learning will become part of our future in Higher Education (HE), according to the Horizon Report for 2011 (Johnson, Smith, Willis, Levine, & Haywood, 2011). Game-based learning is one of six areas of emerging technology that will have a significant impact on HE in the next one to five years, according to the Horizon Report for 2012 (Johnson et al., 2012). In this context, there has been interest in using virtual world platforms such as Second Life and Massively Multiplayer Online Role-Playing Games (MMORPG) such as World of Warcraft to enhance the learning landscape in general.

The Metaverse Roadmap (Smart, Cascio, & Paffendorf, 2007) defines two types of virtual world: virtual-world-based games that are goal-oriented and take place within limitations of the rules of the game; and social-focused virtual worlds that provide various levels of freedom in terms of avatar (the digital representation of a participant) customization and the ability to build and/or create.

Camacho, Esteve, and Gisbert (2011) drew up a classification of the types of platforms and their relationships with virtual worlds and education: (a) 3D toolkit for creating collaborative virtual-world server platforms; (b) Companies dedicated to providing services in 3D environments; (c) MMORPG (Massively Multiplayer Online Role Playing Games).

The four dimensions stated by De Freitas (2006) when selecting and using games for learning, context, mode of representation, pedagogical approach and learner specification could become a starting point for practitioners who wish to begin using virtual worlds in their learning practices.

Virtual worlds are not merely 3D multi-player games. The immersive, rich experience that such environments provide combines many of the features of Web

2D, such as group instant messaging, voice chat, profiles and real-time social networking, and a unique form of online social interaction that involves sharing objects and creative collaboration on building and running places and services in the virtual world (user-generated content). De Freitas (2008) lists the recurring characteristics of virtual worlds: shared space, persistence in the environment, the user's avatar as a representation, interactivity, and immediacy of action (so that interactions occur in real time), while similarities with the real world, such as topography, movement and physics, provide the illusion of actually being there. Educators can design the learning space for pedagogy, rather than the other way around as in some off-the-shelf 2D virtual learning environments (VLEs).

Duncan, Miller and Jiang (2012) presented a taxonomy of virtual worlds, which indicates that several areas of potential research and development exist, including suitable educational activities and learning environments, correct supporting technologies, revised learning theories, and experimental and verifiable evaluation practices.

Participants in a successful virtual world have a deep sense of presence in that world. To experience the potential of learning in an immersive world, 3D virtual worlds have a considerable importance and potential for a training and knowledge-sharing environment. Girvan and Savage (2010) identify the type of activity that most suits the affordances of virtual worlds as that of social and communal constructivism, in which learners co-create virtual objects for themselves, other learners in their group, and subsequent learners in the environment.

Method

We have used mainly descriptive methods to analyze data gathered through participant and non-participant observation and documentary analysis (video, chat, images and other interactions), taking a validated rubric of the skill of self-management as a reference.

Participants and the Learning Context

The participants were 57 university students of Education (75.4% female and 24.6% male) with a mean age of 23.34 (sd = 5.18) during the 2010-2011 academic year.

Students in groups of three members were required to organize a "Scholar Olympic Games" in the multi-user virtual environment of Opensim; in terms of Kemp, Livingstone, and Bloomfield (2009) this virtual environment was integrated with a Moodle learning-management system by means of the Simulation Linked Object Oriented Dynamic Learning Environment (SLOODLE). SLOODLE enables the communication process between objects in the virtual world and assignments in Moodle.

The didactic proposal consisted of a project-based learning structure. In this project, students had to put active learning into practice by integrating game elements in order to promote challenge and competition to enhance performance. The didactic project was developed by means of a simulation strategy in four phases: preliminary, planning, construction and reporting (Figure 1).

In accordance with this structure, the training activity proposed by the teacher consisted of an activity in which students in groups of three were required to construct a project within the 3D simulated environment. The project the students were asked to construct was a school Olympics in which they could propose any kind of Olympic sport.

The 3D environment contained a central island with general guidelines for the activity, a chat tool and 3D objects previously created for use in the construction. Each group was assigned its own space in which to carry out several activities set by the teacher and related to the skill of self-management.

Below we describe the four phases of the project:

- *Preliminary*: The students were introduced to the environment in a face-to-face session in which they made contact with the environment and the general project was explained. This phase concluded with the formation of groups.

Figure 1. Phases of the didactic project.

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- *Planning*: The students developed a set of specific activities in order to accumulate points that they could exchange for resources at the end of this phase. The activities were related to the specific content and had different characteristics: organization, elaboration, anticipation and explanation/ justification.
- *Construction*: Each group built its project by creating its own resources and managed the resources they had earned in the previous activities.
- *Reporting*: Each group presented and defended its project before a committee of experts.

During the period of training, several agents participated in the project: the teacher monitored the whole learning process, designed the educational training activities, and provided resources for students; a collaborator supported both the teachers and the students if they faced technical problems with the 3D environment; and Simul@ project researchers were responsible for observing the whole process in order to collect data and conduct the subsequent analysis. These three profiles (participants and non-participant observers) were responsible for collecting the relevant information for completing the various instruments used in the experiment.

Self-management and the corresponding dimensions (see Figure 2) were assessed using an analytical rubric developed and validated in the Spanish research project Simul@. This rubric is organized at various levels ranging from generic dimensions to specific elements and indicators.

To evaluate the students' self-management during the activity, a recording system was organized in which the rubric was taken as reference. The information was collected in two ways from actions that took place during the activity and from

	DIMENSIONS	*ELEMENTS*	*INDICATORS*
MANAGE	S1. Planning	S1.1 Motivation S1.2 Analysis of proposal S1.3 Formulation of objectives S1.4 Task planning	Set of indicators (scale of 1-4) that take the elements as reference
	S2. Organization	S2.1 Time management S2.2 Assignment of responsibilities S2.3 Assumption of responsibilities S2.4 Estimation of resources S2.5 Location/selection of resources	
	S3. Development	S3.1 Action S3.2 Monitoring	
	S4. Assessment	S4.1 Assessment criteria S4.2 Improvement orientation	

Figure 2. Evaluation rubric.

substitute: SELF-MANAGEMENT

Change location of this Figure 1. This must be located before the second paragraph in this page "To evaluate the students' self-management during the activity..." (line 21) interactions generated in the virtual environment by means of chat, videos, and images. The chat logs mainly constituted the raw data containing relevant information for estimating the student's level of performance with respect to a specific indicator expressed in the rubric.

The final project of each group was evaluated by observing the final construction in the group's own space. These spaces (islands) were assessed by six evaluators in accordance with three criteria: Organization—the structural arrangement of the objects used in the 3D world; Variety of objects—the range of objects created and used on the island; and Relevance—the coherence and appropriateness of the project requirements.

To further complement the evaluation process, at the end of the training activity the students were asked about their perceptions on using the 3D simulated environment to acquire the skill of self-management.

Analysis Design

After the non-normality condition in our sample was verified using the Kolmogorov-Smirnov test, descriptive and comparative methods were conducted using non-parametric tests. Specifically, we used the independent-samples Mann-Whitney U test to compare means between the groups of students defined by gender and academic level (freshmen or senior). These non-parametric tests are suitable for this kind of variable and are not conditioned by the sample size or shape (Leech & Onwuegbuzie, 2002). For further comparison between groups, the differences are presented in mean ranks between groups; this estimation can be interpreted as an effect size index (Green & Salkind, 2008).

To further investigate the effect of the technological environment, a subsample ($n = 44$) was created by asking the students for their perception of the 3D simulation impact with regard to the dimensions of self-management. A descriptive analysis was developed to report on this.

Procedure

The experiment took place at the end of the second semester of the 2010-2011 academic year and was integrated as a specific activity in the instructional schedule. The activity consisted of a didactic proposal based on a project-based learning structure that integrated game elements to promote challenge and competition and enhance performance. The students were given 4 weeks to develop the project and there were no restrictions on accessing the virtual world.

Instruments

Self-management was assessed using an analytical rubric (see Figure 2) developed and validated in the context of the Spanish research project Simul@. This process constituted a subproject to adapt the skill assessment process to the

3D learning environment. The rubric is organized at different levels of aggregation ranging from abstract dimensions to specific and concrete elements that are measured by indicators on a 1-4 scale (level 1 = deficient; level 2 = marginal; level 3 = good; level 4 = excellent). This scale was recalculated to a range of 1-10 to transform it into an ordinal variable: scores of 0-2.5 = level 1; 2.5-5 = level 2; 5-7.5 = level 3; and 7.5-10 = level 4. Examples of the indicators used in the rubric are "2.3. Assumption of responsibilities": (1) he/she does not assume the responsibilities assigned; (2) he/she assumes some of the responsibilities assigned; (3) he/she assumes assigned tasks efficiently; (4) he/she assumes tasks efficiently and promotes the adoption of the responsibilities by others." The scores for the dimensions were calculated as the arithmetic means of their elements. This rubric was used for the assessment process during the training activity.

To evaluate the final project we used an ad hoc built tool that consisted of a scale of 1 to 10 with an open space for qualitative comments to be provided by evaluators after they had observed both the final projects and the students' presentations.

To estimate the students' perceptions on using the 3D learning environment, we used a questionnaire in which the students indicated their perception according to the elements of the skill of self-management. This perception was valued as indifferent, negative or positive (codified by 0, 1 and 2, respectively).

Results

We present our results based on the description of self-management, taking the rubric levels as reference and comparing the elements and dimensions of the skill (see Table 1) by gender and academic year. We also present the students' perceptions on the simulation effects (see Figure 3).

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After a general overview, our results suggest that the students in the sample performed at a good level academically with regard to the skill analyzed. We can also affirm that both the 3D simulation environment and the didactic proposal contributed to this high level of achievement.

Taking dimension as the unit of analysis, we find that only Dimension_Assessment (mean = 7.96) fell into the category of excellent. The other three dimensions fell into the category of good. Dimension_Organization presented scores (mean = 7.37) that were close to excellent, while the other two dimensions lay in the middle of the good range and had similar scores (mean = 6.31 for Dimension_Planning and mean = 6.22 for Dimension_Development).

When we observe the rubric elements (see Figure 4), only the score for Actions belonged to level 2 (Marginal) (mean = 4.54). This contrasts with the score for the other element in that dimension (mean = 7.91), which belonged to level 4 (Excellent).

Two independent-samples Mann-Whitney U tests were conducted to determine the differences between gender and the differences between freshmen and senior

Dimensions / Elements	N	% Freshmen	Mann-Whitney U	Sig. (2-tailed)	Z	r	% female	Mann-Whitney U	Sig. (2-tailed)	Z	r
	Freshmen vs Senior						Gender				
1. Planning	*57*	*24.6*	0	***0.000***	-5.581	***-0.74***	75.4	221	0.138	-1.483	***-0.20***
1.1 Motivation	*57*	*24.6*	141.5	***0.003***	-2.958	***-0.39***	75.4	169.5	***0.015***	-2.438	***-0.32***
1.2 Analysis_of_proposal	*57*	*24.6*	27	***0.000***	-5.095	***-0.67***	75.4	296.5	0.933	-.084	***-0.01***
1.3 Objectives_formulation	*57*	*24.6*	0	***0.000***	-5.635	***-0.75***	75.4	272	0.587	-.543	***-0.07***
1.4 Tasks_planning	*57*	*24.6*	0	***0.000***	-5.635	***-0.75***	75.4	272.5	0.594	-.534	***-0.07***
2. Organization	*57*	*24.6*	6	***0.000***	-5.488	***-0.73***	75.4	212	0.098	-1.656	***-0.22***
2.1 Time_management	*57*	*24.6*	20	***0.000***	-5.257	***-0.70***	75.4	254.5	0.384	-.870	***-0.12***
2.2 Assignment of responsibilities	*57*	*24.6*	0	***0.000***	-5.623	***-0.74***	75.4	239	0.247	-1.158	***-0.15***
2.3 Assumption of responsibilities	*57*	*24.6*	6	***0.000***	-5.513	***-0.73***	75.4	201.5	0.063	-1.860	***-0.25***
2.4 Resources_estimation	*57*	*24.6*	36	***0.000***	-4.934	***-0.65***	75.4	216	0.114	-1.583	***-0.21***
2.5 Location_selection_resources	*57*	*24.6*	101	***0.000***	-3.805	***-0.50***	75.4	248.5	0.318	-.999	***-0.13***
3. Development	*57*	*24.6*	22	***0.000***	-5.174	***-0.69***	75.4	207.5	0.083	-1.734	***-0.23***
3.1 Actions	*57*	*24.6*	127	***0.001***	-3.230	***-0.43***	75.4	173.5	***0.018***	-2.367	***-0.31***
3.2 Monitoring	*57*	*24.6*	5	***0.000***	-5.530	***-0.73***	75.4	296.5	0.933	-.084	***-0.01***
4. Assessment	*57*	*24.6*	50	***0.000***	-4.668	***-0.62***	75.4	281.5	0.717	-.363	***-0.05***
4.1 Assessment_criteria	*57*	*24.6*	150	***0.005***	-2.821	***-0.37***	75.4	265	0.501	-.673	***-0.09***
4.2 Improvement_orientation	*57*	*24.6*	0	***0.000***	-5.631	***-0.75***	75.4	290.5	0.844	-.196	***-0.03***

Note: (*) Significance level = .05.

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Indicate caption of this " Table 1: Mann-Whitney U tests for gender and level of study"

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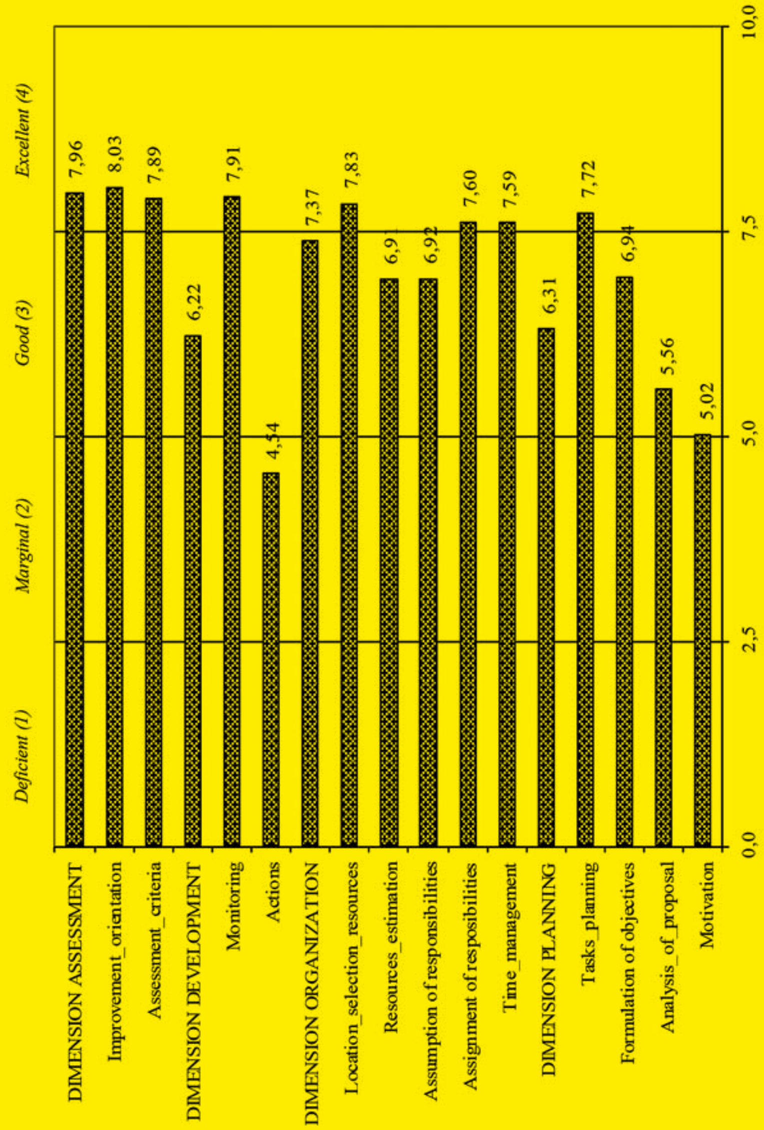

Figure 3. Means scores of elements and dimensions in the sample.

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students. Both these analyses were conducted with regard to the elements comprising the four dimensions of self-management and the corresponding elements.

Table 1 shows that two elements presented significant differences with regard to gender: these were Motivation and Actions, where males performed significantly better than females. In fact, both elements had medium effect sizes: *r* index = –0.32 and –0.31, respectively.

With regard to differences between levels of study, senior students performed significantly better than freshmen in self-management regardless of the reference taken (dimensions or elements). All elements and dimensions presented medium or large effect sizes: specifically, the *r* indexes ranged from –0.37 to –0.75.

Figure 4 shows that the effect of the simulation on the students' perceptions of self-management was mostly satisfactory. From the total amount of data, we find that the students' positive perception was over 72% while their negative perception was only 10.5%. Taking the dimensions as our reference, we find that Assessment (75% positive) and especially Planning (87.5% positive) presented the highest percentages of Positive items. On the other hand, Development presented 22.7% of Negative items. Finally, the highest percentage of Indifferent items (22%) was presented by the Organization dimension.

DISCUSSION

The first results to discuss are the differences observed between freshmen and seniors. These suggest that there is a gap between compulsory and HE regarding the development of self-management. This general skill, understood in terms of

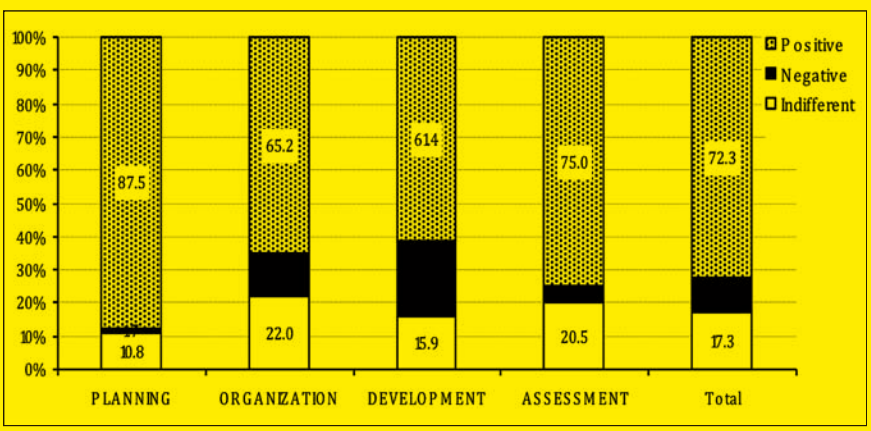

Figure 4. Perception of the simulation effect in percentages.

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While self-management is better developed at university than in high school, Education students tend to perform better in analytical activities such as monitoring, planning and assessment than in activities involving action. In fact, all the activities involving action during the project showed a lower development than the rest.

Use of a 3D simulation environment enhanced the possibility of implementing all kinds of actions in an integrated manner. These technologies enable the proposal of learning activities that put the students at the center of an action process and provide us with a detailed register of the students' activity. This allows us to conduct proper monitoring and further assessment.

According to numerous authors (Gisbert, Cela-Ranilla, & Isus, 2010; Alrayes & Sutcliffe, 2011; Duncan, Miller, & Jiang, 2012; Girvan & Savage, 2010), current research reinforces the idea of using 3D simulation tools by creating learning environments in which generic skills such as self-management can be developed. However, our study has also underlined the importance of designing an effective didactic proposal for the whole process to succeed. In fact, one question that arises is the extent to which using a project-based activity played a critical role in the success of the learning process.

Based specifically on our results, it is interesting to note that despite the suitability of the environment for satisfactorily completing the learning process, the students did not feel highly motivated or particularly encouraged to act. This idea is reinforced when we observe how participants perceived the effect of the simulator on the learning process: they expressed their preferences for tasks that involved analytical work rather than those that involved action and development. This may be related to their traditional ideas of the academic setting and their self confidence in a technological learning environment that is very new for them, at least in that setting. Exploring the students' experiences from a more qualitative perspective will be useful for analyzing this kind of approach in these technological environments.

One challenge we face is the need to collaborate to design a process for assessing the performance of the participants. The process used in this work can be taken as a first step that can be improved by employing technical tools such as those used in artificial intelligence (Morillo et al. 2010). This would be a step forward that would help to overcome the traditional handicap of observer subjectivity in Education research.

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