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ICTs and Learning: A Challenge in the Engineering Education*

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The present educational context of higher education in the European Union shows the importance of developing a teaching based on learning. Information and Communication Technologies (ICTs) favor the development of a more active role of students by means of the creation of a flexible and an interactive learning where student is the centre. These technologies have been incorporated in engineering degrees too where learning based on experimentation and exploration acquires a great relevance.

The objective of this paper is to study the role of ICTs in the learning process of engineering students in a subject of Economy. In this context, we analyze the learning results obtained by students of computer engineering before and after the use of a learning virtual platform. At the same time, the main advantages of such tools are discussed. Results indicate that these students obtain a better learning by means of the use of ICTs.

Keywords: information and communication technologies; learning; knowledge; engineering; economy; virtual learning

1. Introduction

The design and development of learning platforms based on Information and Communication Technologies (ICTs) are a key concept in the process of teaching-learning. The World Conference on Higher Education of UNESCO in 1998 establishes the importance of ICTs in the educational field with the aim of "*reinforcing the academic development, extending the access, getting an universal diffusion of knowledge and making education easier*". Two years later, European Commission embarked on a new initiative "e-learning-designing tomorrow's education" that remarks the e-learning potential to the knowledge society, the improvement of the learning quality, the facilitation of the access to learning processes and the obtaining of learning and formation more efficient in the workplace. In 2003, European Commission establishes "e-learning multiannual program (2004–2006)" to develop an effective integration of ICTs in the European educational systems. The subsequent programs "Education & Training 2010" and "Education & Training 2020", approved by the European Commission, emphasize in the importance of ICTs in the educational field to obtain a teaching based on learning, this is, one of the main objectives of the Bologna Declaration.

In this context, ICTs allow users to have a support that facilitates the social-communicative process. It involves an effective and efficient feedback that favors a faster learning. Therefore, teaching based on ICTs provides a flexible and interactive learning where user is the centre. It involves the necessity of changing a lot of characteristics of the traditional teaching as: a) the adoption of an active role of student in the learning process, b) users have the learning control, c) the possibility of being a geographic dispersion of users, d) users should have a basic knowledge of ICTs, e) the possibility of developing an individual formation (by means of a personalized process, for example with individual tutorials) and a collective formation (by means of the development of teamwork).

In this context, the main advantages that emergent technologies involve in the education are given by [1–3]:

- *Interactivity*. ICTs allow users to have a more active and contingent relation with the information. Besides, these technologies entail a more active role of users and, therefore, greater motivation and self-esteem of them.
- *Dynamism*. ICTs involve a learning process that can be established in function of the experimentation and exploration (for example, by means of simulations of real situations). It is very motivator because users appreciate the usefulness of the acquired knowledge.
- *Multimedia*. ICTS facilitates the learning generalization by means of different complementary sources (for example, power-point presentations

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for the content of the course, chats for the discussion of the theoretical concepts and on-line tutorials for possible questions about them).
- *Hypermedia*. This tool favors user's active learning by means of the analysis of the different information interrelations. Therefore, the self-esteem and the exploration of different information sources are emphasized.
- *Connectivity*. ICTs allow the creation of an educational platform where the different users and teachers are connected. It favors the transmission and the combination of knowledge, for example by means of the establishment of teamwork and collaborative activities.

These characteristics of ICTs could facilitate the obtaining of the main strategic objectives of the Bologna Declaration that are related to the educational quality and efficient improvement providing an educational system accessible worldwide.

In this context, the objective of this paper is to analyze the role of ICTs in the learning process of engineering students. With this objective, in the next section we study ICTs and the new educational paradigms. Next in the paper we analyze our teaching methodology based on ICTs and the results obtained by computer engineering students. Finally, we draw the main conclusions and the discussion from the paper.

2. ICTS and the new educational paradigms in engineering education

In the present Information Society, ICTs have an essential role in the formation processes. The development of technological platforms involves a greater flexibility in the access and time of learning-teaching processes by means of the adaptation to every apprentice's abilities, requirements and availabilities [1]. Therefore, these technologies allow students to be the centre of their formation by means of the continuous assimilation of knowledge, abilities and competences. Besides, ICTs involve the possibility of establishing collaborative learning environments by means of the use of synchronous (communications are sent and received at different times) and asynchronous tools (communications are sent and received at virtually the same time).

From these characteristics, the main effects of the ICTs on education are given by:

(a) The possibility of establishing a physic separation between teachers and students.
(b) Learning is centered in the student.
(c) The establishment of a multidirectional communication that allows the development of a corrective feedback process. Synchronous tools, as the case of messaging tools, involve this process by means of the getting contact between teachers and students that allows teachers to know students' learning process and to encourage them to obtain new concepts. In the case of asynchronous tools, like forums, students obtain commentaries of teacher and other students until they can obtain the most suitable solution of the proposal case.

Another important concept is the effect of ICTs on information obtaining and transmitting about different types of knowledge. Empirical evidence shows that these technologies have involved the generation of the four basic forms of knowledge model [4]: socialization, exteriorization, combination and interiorization.

These characteristics of ICTs are suitable in the new context of the European High Education Area. The Bologna Declaration establishes the necessary characteristics to build a common European education system where life-long learning, the establishment of the European Credit Transfer System (that seeks a student-centered education with the aim of students can obtain the competences of their degrees) and the transnational education are emphasized.

Therefore, the establishment of learning aims in terms of competences, with the objective of getting the necessary professional requirements in the labor market, and teaching based on learning involve a change of the traditional methodologies and of teachers' role. ICTs supply an appropriate system to establish a more flexible teaching where student is the learning centre and to develop new methodologies that allows students to acquire the required competences. So, these technologies are the basis of the virtual learning platforms where synchronous and asynchronous tools allow students to create tacit and explicit knowledge.

Empirical evidence shows that ICTs have different effects on students' performance. On the one hand, some research obtains that these technologies does not have the expected positive effects on students' performance [5–7]. These studies obtain greater marks of face-to-face methodologies than on-line methodologies. The main explanation is the lack of self-discipline necessary for successful independent learning in the online environment. Besides, students can use ICTs to increase their leisure time and have less time to study. On the other hand, an extensive literature obtains that ICTs have positive effects on students' performance. [8] show that web-based teaching supports active learning processes emphasized by constructivist theory with the consequent positive effects on students' performance. [9] analyze a subject of

economy degree and obtain a positive impact of these technologies on student performance although all used tools involve this result. [10] obtain that on-line methodologies have positive effects both on students' attitude and their achievement. Similar results are obtained by [11] and [12] who show that the establishment of ICTs in higher education involves a collaborative work between students, positive interdependences and enhance group productivity. In this context, [13] establish the importance of developing an organizational change in universities that allow users to use ICTs in a suitable way. It could be a key concept to obtain the expected results from the use of ICTs in higher education.

In engineering degrees, a key concept is the acquisition of competences that allow students to give solutions to future problems that would be able to find in their career. Therefore, learning is a process and not only the acquisition of contents. This process covers from the acquisition of information until their treatment and it involves a change permanent relatively in the students' behavior because of the experience.

In this context, learning by experience or imitation models acquires a great relevance in engineering students [1]. It should involve a substantive link between previous knowledge and the new information. Besides, that link ought not to come from the memorization but the rationale. Therefore, it is important to create knowledge based on experimentation and exploration where collaborative work has an important role too. This learning design will have repercussions on personal growing and will contribute to the creation of new knowledge.

Literature about ICTs and learning in engineering degrees indicate mainly a positive impact of ICTs on students' performance. [14] show the importance of the educational software of the NASA where the interactive explorations are designed to involve students in real engineering processes. It allows engineering students to develop a collaborative work in multidisciplinary teams, which will be a key competence in their careers. Similarly, [15] and [16] establish the importance of ICTs in the development of skills associated with creative thinking and self-learning and interaction skills that facilitate collaborative learning in engineering degrees.

3. Analysis of ICTs and learning: The case of an economy subject in computer technical engineering

As was discussed in the previous paragraphs, it is important to integrate the ICTs in the university educational field to promote teaching based on learning.

The development of distance education in the universities (virtual university) creates a different work environment much for teachers as for students. This environment is more flexible to the student's circumstances and the possibility of interaction and possibilities of teacher-student contact that would otherwise not be possible.

This paper focuses in analyzing how the education environment influences learning, and particularly highlights the incidence of the ICTs in the learning process of a subject called ''Business Management in engineering''.

The study consists in a case in which results of the learning process with and without the use of ICTs in the teaching are compared. The results highlight the importance of the use of ICTs in order to motivate students to participate in the different activities and to get a deeper knowledge of the subject.

The Learning Management System (LMS) tool introduced in the teaching of ''Business Management in Engineering'' was Campus Virtual. The LMS is used to implement a collaborative environment and allows educators to create effective online learning communities, to participate actively in the learning process and to collaborate in groups. The collaborative activities often promote metacognitive processes such as reflection, self-explanation and self-regulation [17].

Campus Virtual has been based on the platform Moodle (modular object oriented developmental learning environment), an open source LMS designed to help educators create quality online courses and administer learner outcomes [18]. This system, nowadays, is the most used and it has been installed at universities and institutions all over the world.

Moodle allows creating dynamic online web sites that involve students and it is designed to support the style of learning called social constructionist pedagogy [19]. This style of learning considers that students learn better when they interact with the learning material, construct new material for others, and interact with other students about the material.

In Campus Virtual is possible to create discussion groups, to ask and answer queries and create tools for monitoring students' progress as exams, assignments and additional study materials for students. These e-learning systems accumulate a vast amount of information very valuable for analyzing students' behaviour. They can record any student's activity involved, such as reading, writing, taking tests, performing different tasks, and even communicating with peers. Log files can be filtered by course, participant, day and activity. Instructor can use these logs to determine who has been active in the

course, what they did, and when they did it. However, traditional classrooms only have information about students' attendance, course information, curriculum goals and individualized plan data [20].

The subject ''Business Management in Engineering'' is an elective subject of the degree in Technical Computer Engineering of the University of Oviedo. This was chosen because allows us to know the role of the virtual tools in learning process as we can compare students' results before and after ICTs were introduced in the teaching. With this purpose, in this study two consecutive academic courses where selected, one before the use of ICTs and the second, the course in which these learning tools are introduced in teaching.

The assessment process of the subject was similar both courses, with the only difference that some tasks were converted into virtual activities or supported by on line tools, when the Campus virtual was introduced in the teaching process. The final mark was an average of the different marks got in the activities proposed along the academic course. Teacher proposed three types of activities: continuous assessment, compulsory tasks, and a group assignment, all of them are detailed below.

Continuous assessment: Besides the use of ICTs, the evaluation of the learning during both academic courses had a common part: after each unit, students had to overtake a brief exam of the contents explained. Students' results from this evaluation are shown in the second column of Table 1. So, students ''before ITCs'' got better marks in this continuous assessment than students who used virtual learning tools. This result can be interpreted in terms of students' level, by this, students before ICTs were more brilliant than students after ICTs.

Compulsory tasks: These tasks changed with the use of Campus Virtual in the teaching process. Before Campus Virtual, teacher asked for several tasks that students solved and handed back. These tasks were:

- Describing the difference between two concepts explained during the lessons.
- Solving some exercises similar to those solved during the class (three times in a course)
- Calculating different economic and financial ratios, considering the information from the annual accounts of a company.
- An individual written assignment, in which student had to get the better decision to a given situation of a firm.

The following courses, when Campus Virtual was introduced, different tasks were designed, trying to use the great variety of possibilities of the platform. Campus Virtual has a broad flexible array of module activities and resources to create five types of static course material (a text page, a web page, a link to anything on the Web, a view into one of the course's directories and a label that displays any text or image), as well as six types of interactive course material (assignments, choice, journal, lesson, quiz and survey) and five kinds of activities where students interact with each other (chat, forum, glossary, wiki and workshop).

Considering that it was a business subject, and also that it was the first course in which this ICT—Campus Virtual— was used; only some of the above activities were applied. Figure 1 shows the contents and tasks used in this year.

These activities were developed as a support of the non-virtually lessons, as it should be the first step when introducing an LMS. As Campus Virtual keeps detailed logs of all activities that students perform, teachers could control the participation of the students in the different task proposed. It is important to mention that not all the tasks were evaluated for the students' final mark.

Next, each proposed task is described, considering if it had been evaluated or not, and indicating the percentage of participation.

(a) Evaluated tasks:

- After the first unit was explained in the class, students must access to the virtual campus and answer a questionnaire (participation 85%).
- As the second unit was explaining, students were filling a glossary with the main concepts of the unit (participation 85%), as a support, they had an explicative video (participation 36%). When

Table 1. Students Marks

Before Virtual Campus	Continuous Assessment	Compulsory Tasks	Group assignment	Final Marks
% 9–10	16.67%	16.67%	11.11%	14.82%
% 7–8	55.56%	33.33%	38.89%	42.59%
% 5–6	22.22%	33.33%	22.22%	25.92%
% <5	5.56%	16.67%	27.78%	16.66%
After Virtual Campus				
% 9–10	7.14%	21.43%	50.00%	26.19%
% 7–8	42.86%	35.71%	28.57%	35.71%
% 5–6	28.57%	35.71%	7.14%	23.81
% <5	21.43%	7.14%	14.29%	14.29%

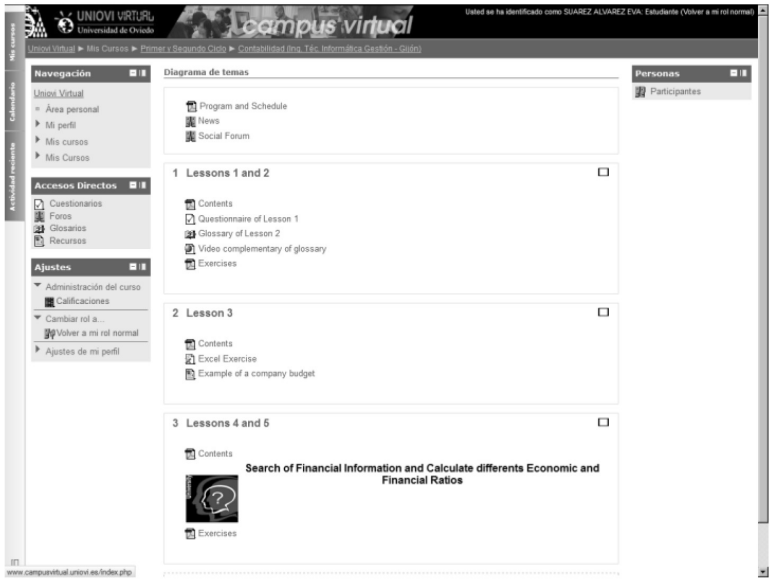

Fig. 1. Contents and Tasks in Campus Virtual.

the unit was over, they solved and send to the teacher, by e-mail, several exercises (participation 78%).

- To assess the learning of the third unit, students should complete a budget table in a spreadsheet (participation 85%) and design a budget similar to one shown in a referenced website (participation 71%).
- In the fourth unit, they should find different financial information in the internet (participation 71%) and later, calculate some financial and economic ratios proposed by teachers (participation 57%).
- For evaluating the last unit, students solve and send to the teacher a pool of exercises (participation 71%).

(b) Non evaluated tasks:

- Participation in different forums: one informative, called ''News'' in which teacher published the task to be done, and marks; another ''Social Forum'' whose objective was to be a place where students could discuss and argue about any aspect or event related with the subject (participation 42%).

Despite of the low participation in the non-evaluated tasks, the positive effects of the introduction of ICTs in the teaching-learning process are remarkable. The third column of Table 1 shows the students' results in these tasks. Although students ''after Campus Virtual'' marked lower in the continuous assessment, their results in these other tasks reached higher values than the marks of students ''before Campus Virtual''.

Group assignment: Once all the lessons had finished, students had to present a written assignment, make in groups, in which they had to study the whole economic and financial situation (budgets, product and cost decisions, patrimonial structure analysis . . .) of a company chosen by the teacher between a pool of companies from different economic sectors. This kind of tasks allows students to improve their competencies through the collective learning. Written assignment marks are presented in the fourth column of Table 1. These marks shown that students who have used ICTs in their learning process, had obtained better marks, and therefore had developed in a more efficient way their capacities as working in group, finding information, for example; than the students of the first course considered who do not follow any virtual learning.

The main advantages of using this platform, for good practice in education [21], are suggested in [17]:

- It increases the student contact time with their teachers and others students through forums (asynchronous tool) or chats (synchronous tool).
- It encourages the collaborative work among students, allowing the sharing of knowledge and ideas.
- It encourages active learning; students remember much better what they say and make what they hear.
- The students can schedule their learning time, since the web platform is available 24 h.
- The collaborative work in the platform offers the students the possibility of showing their talents and learning from the others.

- It offers auto-evaluation tools, which give a feedback of the learning process to the student.

Related to the participation level, it is important to remark that this was the first time that virtual campus was introduced in the learning process, and it could be the reason for the low degree of participation in some of the activities proposed. [22] supports this results but, when asking students, they argue that they are not aware of the features, lack of time, or simply because they believe they have no use for them. Another disadvantage is that there are still some technical problems when using platform Campus Virtual mostly caused by hardware and software limitations of the employed servers.

Final marks (last column of table1) confirm the benefits of using ICTs as students improved their final results. An increased of the best marks and a reduction of the percentage of falls are reflected in it. So, results of our study indicate that Campus Virtual's activities are useful for both, students' own learning and also for collaborative learning. The aspects more positively valued by students were the flexibility provided and that the courses were customized to their convenience, study habits and personal learning preferences.

4. Conclusions

The requirements of knowledge societies indicate the importance of establishing a continuous formation and professional specialization from flexible learning programs. In this context, the development of ICTs is a key concept. These technologies favor the creation of virtual learning platforms where: a) there is an universal information by means of these tools that allow students to obtain knowledge directly, b) new methodologies and self-learning are established with the aim of awaking students' critical thinking, c) collaborative work is encouraged by means of different tools (social networks, chats, e-mail, . . .) and d) learning based on experimentation is promoted by means of the study of real cases or hypothetical cases that students will have to analyze in their future careers.

Therefore, ICTs involve the development of different tools (wikis, blogs, chats, social networks . . .) that allow students to create and share knowledge. Nowadays, teaching based on learning has a special relevance. It entails the necessity of a change of teachers' roles because their main activity is not the information transmitting but the development of suitable learning spaces to guarantee students' self-learning and collaborative work. Besides, teachers should take innovations courses where learn about the Web 2.0, the functionalities of the virtual learning spaces in their universities and the application of ICTs in their teaching as a methodological innovation tool.

Likewise, universities must have the necessary infrastructures for using these technologies in a suitable way. It involves the creation of great servers to manage intranet at university, a fast surfing on the Internet, and the availability of multimedia computers. Therefore, the institutional support is indispensable to create a learning based on ICTs in the higher education institutions.

In this context, the objective of this paper has been to study the effects of ICTs on learning in a subject of economy in computer engineering students. Results show a positive effect in the development of the students' learning when using virtual platform. Taking part of the different activities proposed along the course time on the Virtual Campus; improve capacities such as collective and collaborative ones. It is supported by the fact that students who follow a semi-virtual learning get better results than those who not. Previous researches [22, 23] had interviewed students and confirm the positive effects found in this study. In the same argue, [24, 25] affirm that Moodle platform prove to be a powerful educational web environment for developing different teaching-learning activities in the frame of various on-line courses.

5. Discussion

Although Spain was characterized by a lower application of ICTs on education with regard to other countries of its environment (and especially regarding leading countries such as to the United States), it has been a constant increase of the application of these technologies on higher education institutions from 1990s. In this context, all Spanish universities have some kind of online applications in their structure. Different possibilities of the development of Intranet have been developed, such as e-learning outsourcing, the creation of university consortiums or the establishment of alliances with enterprises (especially relevant in postgraduate studies).

Besides the challenges of infrastructure design, maintenance and management, it is important that teachers develop new competences, based on knowing the functioning of the different digital tools, by means of the establishment of courses on technological innovation. Finally, it is important to choose the digital resources and contents that favor learning based on students. It involves the establishment of a suitable educational web in function of the competences that students have to acquire. In the case of engineering students, the experimentation and exploration are especially relevant.

The creation of the EHEA has important changes

in European university education, such as the moving from a teacher-centered teaching to a student-centered teaching. In this context, students must acquire a number of competencies to the development of their career. To this end, it takes a more relevant education based on learning.

A support element for the development of new teaching methodologies that would meet the objectives of the Bologna Declaration is the ICTs. Such technologies are supporting the creation of more flexible environment for learning and removing barriers in the space-time interaction between teacher and students. In fact, the development of e-learning has generated a multitude of applications that are really relevant in engineering education.

Once on-line tools have been introduced in higher education, a key concept should be to increase the communication between universities and extra-university world by means of ICTs. It is important to establish a link between university and enterprise with the objective of universities can generate the required competences in the labor market. In this context, entrepreneurs could detect the necessity of new abilities in their future engineering professionals as a consequence of changes in their environment. Therefore, the necessity of establishing a flexible communication system that allows universities to know such information quickly. For example, the present economic crisis in Spain shows the importance of engineers with language skills because a lot of enterprises have been extending their activity in international markets. This necessity is being incorporated in higher education institutions by means of the establishment of degrees in computer engineering whose language is English. Another important concept could be the creation of an online portal where universities can incorporate papers and reports about interesting topics for enterprises. It would include labor offers and demands, courses of universities or free services that students could do to improve their knowledge about enterprises.

Finally, we propose recommendations for similar implementations in computer engineering education. It would be very useful to introduce an online platform in the everyday teaching process, not only as a repository of contents, but also designing activities as questionnaires, search of web page, forum, glossary or Chat, that would improve the development of different competencies that computer engineering students have to acquire before finishing the degree. Although this kind of tasks are high valuated by students, teachers are not involved enough in the use of ICTs. So it is necessary to encourage teachers in introducing virtual activities in higher education.

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