Economics for Engineers or Engineering Economics?

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ABSTRACT

This paper summarizes the results of an educational innovation project which has been progressively implemented since 2002 in various engineering degrees at the University of Oviedo. It was based on the experience of a group of professors and lecturers whose professional profile covers both economic and engineering fields. The final aim of the project was to increase the interest of the students in this kind of courses by means of stimulating their curiosity and the perceived utility of the knowledge and skills acquired. This was achieved by the introduction of information technologies not only as e-learning tools but also as part of the learning competencies that all engineering graduates should have acquired during their studies.

The results of the project have been measured by both objective and subjective indicators: the numerical grades obtained by the students in the courses and their personal evaluation of the contents, learning methods and skills achieved. As well as this, the time consumption of the different learning activities has been recorded for every student and the evolution of these records has been analyzed.

Keywords: engineering, economics, educational innovation, e-learning, time management.

1. INTRODUCTION

Courses on economics and business are always included as part of the program of studies in all engineering degrees. There is no discussion on this point, as all professionals agree on the importance of economic feasibility in any engineering discipline. Despite this, the educational experience shows that engineering students are sometimes reluctant to study this kind of courses, not so closely related to technical disciplines. This perception of irrelevance seems to be more intense in first year's students and it is softened as they advance in their studies.

This problem has been observed in different engineering disciplines, such as Mining, Chemical, Electrical, Mechanical, Civil and Environmental Engineering, as well as in various levels of study (not only undergraduate, but also postgraduate students). Anyway, this problem is not restricted to economic courses in engineering degrees, and lecturers frequently mention a more general problem of students specializing in one subject area being reluctant to study material in an area peripheral to their main interest: languages for engineers and science professionals in general [1], [2], mathematics and physics [3] or law [4] for health professionals, etc. In these cases, all authors agree on the need to consider the subject-specific needs of specialists in a given field.

2. AIM OF THE PROJECT

This paper summarizes the results of an educational innovation project which has been progressively implemented since 2002 in various engineering degrees at the University of Oviedo. It was based on the experience of a group of professors and lecturers whose professional profile covers both economic and engineering fields and who are responsible for diverse courses on economics and business. The target courses were integrated in Mining (1st and 4th year), Process (5th year), Bioprocess (5th year) and Environmental (5th year) Engineering studies. The average number of students ranges from 40 to 60 approximately. All the courses carry a value of 6 or 7.5 ECTS credits (1 ECTS credit is equal to roughly 25 – 30 hours of student work including 10 hours of work in the classroom).

The final aim of the project was to increase the engagement of students in this kind of courses by means of stimulating their curiosity and the perceived utility of the knowledge and skills acquired. This should lead to an improvement in the students' performance in the courses [5], [6].

3. METHODS

Screening and monitoring

The first step of the project was to determine the extent of the problem. Diverse screening methods were used for this purpose.

Time management report: Personal time management plays a key role in the educational process. Different habits influence the time consumption of different activities and therefore are important determinant of time management success in learning [7].

During the whole semester in which the courses were undertaken, students were asked to keep a record of the time devoted to the course. This time was classified in the following activities: attendance to lectures, personal study, problem and exercise solving (individual), problem and exercise solving (group) and project development (group). The records of every student were called "Time management report" and were collected and analyzed at the end of the semester.

Final personal report: Self-report measures have been used by many researchers to assess the behavioral, cognitive, and affective aspects of student engagement [8]. Students are asked to report on factors such as their attention versus distraction during class and the mental effort they expend on these tasks. Affective engagement questions typically ask students to rate their interest in and emotional reactions to learning tasks on indices such as choice of activities, the desire to know more about particular topics, and feelings of stimulation or excitement in beginning new projects.

After the semester final grades were known, students were asked to write a "Final personal report" analyzing their performance and results in the course, what they had expected and actually found, which activities and contents they found more/less interesting or challenging, what they missed, their suggestions, etc. They were also asked to compare this with other courses undertaken in the same semester.

Final grades: The above-mentioned monitoring tools, together with the evaluation of the students' performance (measured by the numerical grades obtained) have been used along the eight years of implementation of this project. The information obtained in the fist year was used to make a diagnosis of the situation by describing in detail the starting point. Since then, it has been used as a result monitoring system for feedback.

The diagnosis

According to the information obtained in the first year, the initial situation was very similar in all the target courses and can be described as follows:

- The average time spent by students in the different activities was distributed as shown in Fig. 1. The most time demanding activity was personal study, closely followed by lecture attendance. Problem and exercise solving (both individually and in a group) plus project development scarcely added up to 16% of the whole time devoted to the course.
- In their final personal reports, students stated that the contents of the courses and even the textbooks were excessively theoretical. They were interested in a more practical approach, with more problem solving sessions and more examples from industry.
- The perceived utility of the courses was quite low. The students found low apparent connection to real life in the materials studied. Specifically, they could not imagine any practical implementation in their future careers.
- Paradoxically, despite this lack of interest the students' performance was not worse than in other more technical courses, especially in the upper levels. Students who were close to finishing their degrees seemed to have developed a kind of "mechanical study discipline" that allowed them to assimilate any material avoiding any personal criteria.

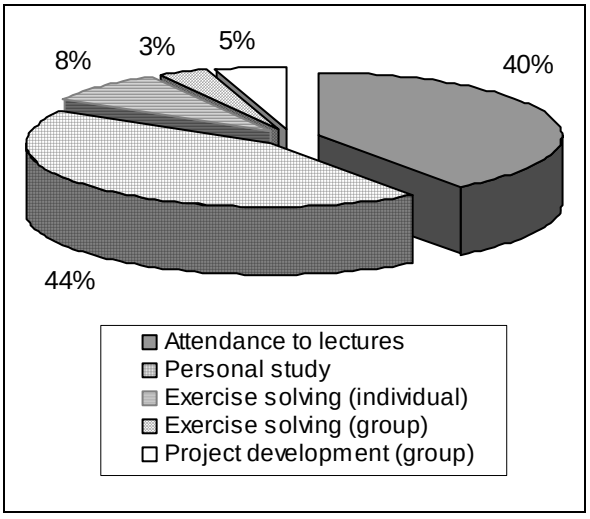

Fig. 1 Time management report results (DIAGNOSIS)

The treatment

Once the problem was diagnosed, a treatment could be planned to solve it gradually. The courses needed a deep change in approach and methods. We needed to persuade students that a subject they saw as irrelevant could be

very important in their career. As well as this, we knew that the courses should be more practically oriented than those similar ones included in social science degrees.

Economics and business are part of everyday life and the sources of information are countless. It was a matter of demonstrating to the students how these subjects influence personal and professional life. It was not difficult to find real examples, specific to the area of specialization, where the lack of economic feasibility had spoiled a technically feasible project. This was a really good point to start with.

It was even possible to find former students working in fields directly related to the subject who could give a talk at an appropriate moment in the semester. We found engineering colleagues working in production forecasting, planning and control, investment valuation, project finance, occupational health and safety, environmental and quality management, accounting and even marketing.

The e-learning platform: As textbooks had demonstrated to be rather unexciting, most of them have been replaced by other information sources, such as press, radio and television. Electronic communication media are specially interesting. Recent news can illustrate most of the contents of the courses with real life examples.

Different works suggest that an integrated virtual learning environment could engender a move to more autonomous learning by students [9]. Another interesting advantage of this kind of systems is that they ca be used by higher education institutions to increase the availability of lectures to off-campus students [10].

A web platform was developed and implemented to grant the access of students to all the learning materials. Lecturers can upload new contents in real time. The platform includes a forum for the discussion of cases, news and articles. As well as this students can upload and share their own documents and materials. By means of this platform, any example found by any member can be shared with all the learning community and later discussed in lecture sessions. Most of the problems proposed along the semester are based on these examples.

One of the most interesting aspects of this innovation is the opportunity to comment and discuss on economic news. With this activity, students discover the most important information sources, become familiar with the specific vocabulary of the subject and learn to understand and analyze economic information critically. Students demonstrate a special interest and satisfaction with this kind of activity and discover the connection of the course to real life.

The lectures: Instructors agree that there is a strong correlation between student participation and performance [11], so we decided to change the structure of the lectures to adopt a more participative model.

With the help of the e-learning platform, the development of the lectures has evolved significantly. Most of them cannot be called lectures any more but seminars. Students participate more actively and their contributions are richer. The number of strictly theoretical explanations has been reduced and they have been replaced by more practical activities, such as case studies and discussions. Since the implementation of the platform the lecturer is no longer the only one teaching in and outside the classroom. Cooperative learning is encouraged.

Computer room sessions: There is a wide variety of software applications for almost any business process. Thus, why should students be content with using just a pen and paper to solve problems and exercises? The computer room offers a good opportunity for students to be trained in the use of different software packages.

Because of this, many theoretical lectures in the classroom have gradually moved to the computer room. Part of the interest of these sessions is in the fact that students can learn to use popular software suites to quickly solve problems already solved in the classroom. For example, a very interesting and simple exercise is the simulation of a mortgage loan using the actual terms offered by a bank (this information can be obtained from its web page), a spreadsheet and the financial functions. Another popular application of the spreadsheets is the simulation of a market using the demand and offer curves and varying the parameters on which they depend (an interactive approach to a very theoretical postulate).

The other point of interest in these sessions is that students can become familiar with very specific software designed for particular business processes, such as forecasting, production planning, Material Requirements Planning (MRP), Enterprise Resource Planning (ERP), decision making, accounting, business simulation, etc. Skills in the use of this kind of software applications are increasingly appreciated by companies

Teamwork projects: There is no doubt on the advantages offered by considering a teamwork-based methodology with university students [12]. On the one hand, it enables students to experiment and acquire the skills that they will need in their future jobs [13], such as interpersonal communication, teamwork, group problem-solving, leadership, negotiation and time management. Project based learning has been established in the field of engineering as a significant experience, promoting cognitive activities and long-life learning [14], [15].

Taking this into account, every semester a teamwork project is proposed to students. They are organized in small teams (4 to 7 members) and each team is given a topic to work on. The topics differ from one course to another. In some cases they have to work on the characteristics of the different types of societies and their suitability for a specific business. In other cases, each team is asked to valuate a specific company in their area of interest, or to develop a whole business plan for a new company.

The results of their work are presented in a lecture in which the lecturers are the students. Every semester the final exam includes one or more questions on the contents of these lectures.

This activity is not compulsory, but students are given an incentive to take part in it by taking into account their contributions for the final grade.

The electronic whiteboard: The most recent step has taken place this year, with the implementation of the electronic whiteboard. Recent works have been published on the advantages of using automated capture and access systems to capture the materials presented in lectures [16].

This year for the first time we are collecting all the information generated during the lectures and the participative class sessions and we upload the documents in the learning platform for later review by students. It is too early to judge for the moment, but we expect good results from this new procedure, especially for students who do not attend lessons regularly [17].

Contents of the courses: The important changes in the courses have been done in the teaching and learning methodology and materials. The contents learned have not changed essentially. It is the approach that has changed.

Evaluation system: There have been no important changes in the evaluation system, apart from the fact that the contributions of students to the teamwork projects proposed are taken into account for the final grades. The main component of the final grade is the final exam grade. The final exam is a written exam that includes everything that has been studied in the course and covers both theoretical and practical contents, with applied questions, problems and exercises. This type of exam has not substantially changed since 2002.

4. RESULTS

The monitoring system described above was used to evaluate the results of the project.

Results from the time management reports

The average time spent by students in the different activities is currently distributed as shown in Fig. 2. The distribution has progressively evolved from the one depicted in Fig. 1 to the present one. The differences are very significant.

First of all, we should say that the average time (in absolute terms) devoted to the courses by the students has increased slightly. A new activity has been introduced, which takes 18% of the time consumption: computer room sessions. This activity has directly reduced the time devoted to lecture attendance and both together sum up to 37% of the time of the student, representing the classroom work. The time distribution between the six types of activities is much more balanced than in 2002. Personal study only consumes 14% of the time, whereas problem and exercise solving (both individually and in a group) has risen to 35% of the time. This latter activity, in conjunction with project development, sum up to 30% of time. It means that students spend almost a third of their time devoted to the course working in teams.

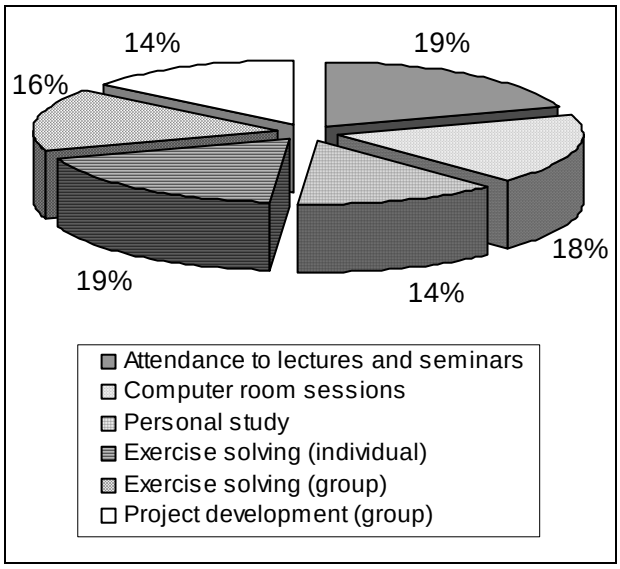

Fig. 2 Time management report results (CURRENT SITUATION)

Results from the final personal reports

The final reports collected along the last seven years show an interesting evolution in the perception of the course by students. They have shown a progressive involvement in the courses, with increasing enthusiasm and interest. They have also offered interesting suggestions on how to improve the different activities, some of which have already been implemented with good results.

Table 1 presents some interesting extracts from the final personal reports of the students collected along these years.

About the lectures: "I think that the participatory nature of the classes has been very important to dispel any doubts that might arise and for people see the course as something enjoyable…" "I think my performance was not bad, but I must say that I've devoted quite a lot of work to the course because I was encouraged by the way classes are developed…" "Giving students the opportunity to solve exercises and problems on the blackboard is a good choice since the lecturer sees where the difficulties are and also implies that students solve the exercises at home…" "Solving many exercises allowed us to understand much easier the theory…"
About the computer room sessions: "The class in the computer room to handle the spreadsheet in terms of financial mathematics has helped me to extrapolate (small scale) the usefulness of economic concepts and their importance in any business…" "I consider the computer classes particularly helpful, because we learned to use interesting programs…"
About the teamwork projects: "The lectures used to share information about our projects were a good idea, because on one side it took us a bit away from the routine of a regular lectures, and moreover it enabled us to learn some things by ourselves. In short, it seemed a good alternative to the traditional explanation of the issues…"
About the course: "At first, it seemed to me very inappropriate to take a course in economics in an engineering degree. Now I think it was very interesting, because I've realized that what we've learned helps us to understand many things of everyday life, like any advertisement of mortgage loans (interest, APR), accounting things (like a letter from the bank) or how the economy of our country works and how companies operate and are regulated…" "I believe that the knowledge gained in this course can be quite useful not only for my academic training but for everyday life (understanding the economic news, requesting a mortgage...). I hope to extend these basic skills in the future because I think they have huge practical application…" "I liked this course more than others and so I spent much more time studying it…" (Erasmus Student from Germany)

Table 1 Some extracts from the students' final personal reports (2003 - 2009). Translated from Spanish.

From the final personal reports we can conclude that the innovations in the courses have worked quite well to achieve the aims proposed for the project. The students' attitudes towards the course have changed significantly. From a subject perceived as peripheral which was considered in many cases as a waste of time, economics and business have turned to be a challenging subject that seems to be useful both for personal and professional life.

Results from the final grades

Fig. 3 presents the evolution of the average numerical grades (from 0 to 4) obtained by the students in the target courses since 2002 (the project started in 2002/2003 academic year). We have depicted separately the grades of regularly attending students and non-regularly attending students (absent), as the differences are meaningful. It is important to state that the type of exam has not varied significantly, so the evolution in the records cannot be explained by changes in the evaluation system.

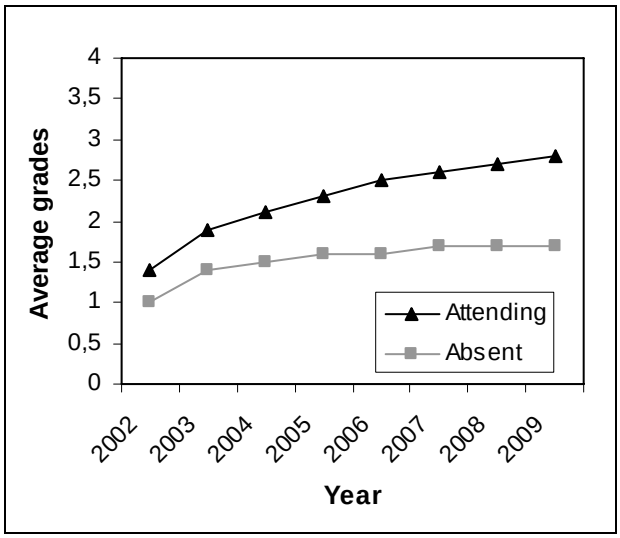

Fig. 3 Evolution of students' average grades in the courses. Regularly attending students (Attending) and non-regularly attending students (Absent)

Considered as an objective measure of students' performance, numerical final grades have increased significantly for both types of students. The most important increase was registered in 2003, the first year of implementation of the project when the most relevant changes took place. The rise in grades has been more intense in the case of regularly attending students (the positive correlation between attendance and performance has already been stated in different works [11]). This is consistent, considering that most of the changes have been done in the class sessions. Despite this, the innovations have also helped students who do not attend lessons regularly. This is probably an effect of the implementation of the e-learning platform, which explains as well why the increase in their grades after the first year has been much softer. The results of the present academic year have not yet been recorded, but we expect better results from non-regularly attending students due to the introduction of the electronic whiteboard.

The average final numerical grades of the students in the target courses are at the moment much higher than the ones obtained in the rest of the semester courses.

5. CONCLUSIONS

The main conclusions of the present experience can be summarized as follows:

- The use of e-learning technologies and information technologies can be a good system to link the contents of a course to real life.
- The introduction of specific examples from the area of specialization of the students contributes to this perception of utility.
- The discovery of this connection by students increases their engagement and interest in the subject.
- There seems to be a positive correlation between students' engagement, dedication and performance in a course, according to the results measured in terms of final numerical grades.
- The average grades in the target courses are significantly higher than in the rest of the semester's courses. Are we consuming too much of our students' time in our courses?

6. FURTHER WORK

The effects of the implementation of the electronic whiteboard have not yet been measured, but they are expected to be positive, especially for non-regularly attending students.

A deeper analysis should be carried out to determine the correlation between the time devoted to each learning activity and the student's performance.

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