A Collaborative Learning case study: Mathematics and the use of specific software

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This paper presents a short study about how to develop a collaborative learning in Mathematics subjects. We try to integrate traditional education in a new one, with the help of technological tools. This integration involves the change and renovation in the didactic processes, the use of different software, educational infrastructures and practices. We presented a valoration of the collaborative learning in mathematical classes that we teach, insisting on the importance that these subjects have in the education of the industrial engineer.

Keywords Collaborative Learning, mathematical software, teaching-learning resources

1. Introduction

Collaborative activities during mathematical classes have been known to improve students' preparation before their future work. We present in this communication a new vision of the mathematical classes, using the Information and the Communication Technologies (ICT) as learning tools, allowing the interaction and the individual contribution like the interchange of ideas and knowledge between the students, who work together to develop their skills. The subjects of mathematics distributed in the School of Industrial Engineering of Béjar, of the University of Salamanca, represent perfect surroundings for the collaborative learning using mathematical software. The use of the Technologies throughout the bachelor's degree studies allows the students, as future engineers, to obtain a complete education, so that they acquire the necessary knowledge to face the technological problems, scientific or of similar nature that finds throughout their professional life.

The ICT suppose a modification in the strategies and methodologies that harness the continuous learning of the student, and have become an important instrument of support in the educational innovation in the last years, allowing the personalisation of the learning process, centring now in the learning of the student, and not in the teaching process by the lecturer. Thus, by means of the use of the technologies we were able to integrate different aspects that are novel in relation to traditional education, like the change and renovation in the didactic processes, besides the use of new resources, educational infrastructures and practices. In this study we presented a valuation of the collaborative learning in the subjects of mathematics that we teach.

Informatics media provide a comfortable and fast way to access, represent, and use information. Some of the advantages of their use are the easiness with which it is possible to manage tasks and the speed with which problems can be solved, allowing students to devote more time to understanding and analysing the results than to mechanics and the possible difficulties involved in the solution; students are more eager to work in mathematics with the aid of a computer, since this eliminates routine work and enhances creativity, increasing students' motivation; and the technologies attract students' attention rapidly. Additionally, ICT afford students the possibility of simulating experiments and experimenting with broadly varying situations and comparing them, something that if done "by hand" would in most cases prove very difficult or tedious.

In particular, in our teaching-learning process, we proposed the students the use of specialised software, such as the symbolic calculus packages called Mathematica [12], Maple [2], or Matlab [9], are of special interest. These software packages have an easy-to-understand syntax, since the orders and commands recall the mathematical operations they execute and hence their learning is rapid and intuitive. Moreover, the help offered by these packages is very complete and is illustrated with numerous examples. Programs such as those mentioned above are able to perform operations with real and complex numbers, operations with polynomials and rational functions, matricial calculus with matrices of numerical and/or symbolic elements, simple analysis hence, the manipulation of formulae, the solving of equations, formal integration, the calculation of limits, tensor calculus, etc.

Some advantages of collaborative learning that we appreciate in our daily lessons are that it allows students to work in groups, to discuss different possible solutions of the proposed exercises. The face-to-face work for develop specific functions and procedures to solve problems make students learn how to face with the subject. We started these cooperative and collaborative activities making students to think about different solutions for the first module of the course, to get the needed knowledge about vectors, matrices and vectorial spaces. They must find the way to define vector operation and the properties like Commutativity, Associativity, or Distributivity of vector sums. When finish the module they find an application of those issues in the "real

word". For example, they found issues like the searches by the Internet, some cryptographic applications, or the resolution of circuits.

2. Software and Mathematics teaching-learning process

The Industrial Engineer is a professional able to develop his work by means of the innovation and the continuous improvement of the processes and products with analytical, creative and critical thought enterprising spirit and capacity to lead highly productive equipment. In his professional performance he will have to glide, to analyze and to interpret, to design, to implement, to evaluate, to investigate and to undertake the possible solutions to the needs that appear in the society and its respective work area or company to him [11].

The Technologies of the Information and the Communication appear like an outstanding element in the convergence process of the university to the EEES [3], contributing to the learning, the change of culture associated to the EEES, and to favour the formation of more responsible and active citizens. In addition, the ICT allows a modification in the strategies and methodologies that harness the continuous learning of the students [6]. The new technologies will be, therefore, tools that must help to secure to majors levels of quality in education, and mainly, must try that the education uses, as far as possible, methods nearer the later work of the students and who suppose an approach to the reality [7]. Teaching of mathematics cannot be an exception and it does not have to be apart of the use of these methods. The ICT affects different aspects that are novel in relation to traditional education, like the change in the paper of the professor, who has stopped being a mere transmitter of knowledge to be a mediator in the construction of the knowledge of the students [4]; and the paper of the student has changed since the traditional educative models suitably do not adjust to the processes of learning by means of the use of the ICT [10]. Finally, one is due to have in account that the ICT do not require of the invention of new methodologies, but of a modification in the strategies that harness the continuous learning of the student [9].

As we know, the mathematics is closely, generally, with Computational Sciences. The area of the mathematics is therefore, one of the most adapted for the incorporation of the new technologies, since it is not only one purely formative subject, but is a scientific tool for the students who must help them to solve the problems that are generally throughout their race and in its professional development. The computer science provides a comfortable and fast form to access, to represent and to use the information [8]. Some of the advantages of their use that could be mentioned are:

- The facility whereupon the tasks and the rapidity are managed with which the problems are solved, which allows students spend more time to the understanding and the analysis of the results that to the mechanics and the possible difficulty of its solution.
- The students find the job in mathematics with the possibilities more attractive that the computer offers, since it eliminates the routine work and power the creative part, which increases its motivation.
- He is able to quickly catch the attention of the students.

On the other hand, the ICT provide the students the possibility of simulating experiences and of raising very different situations, and of comparing them, something that manually can be difficult or at least tedious in the majority of the cases. It allows them, for example, to include/understand the true reach of a problem or the effectiveness of an algorithm analyzing the initial results that obtain when varying the hypotheses, conditions, etc. Thus we can mention, in addition:

- To graphically represent successive curves that shows the different solutions from a problem.
- To modify, to suggest to the student the data of the proposed problem and to see the repercussions of these modifications in the solution.
- The conviction power that gives the accomplishment of the calculations with computer in the presence of the students.
- To represent graphically, in seconds, all the solutions of different problems.

Thus, using computers in the classroom, it is possible to offer to the school students' more and more complete and deep formation in mathematics, that allow them to face their future professional activity, adapting to the advances of science and technology. From the appearance of computer science, one of the main utilities of the computer, in relation to the mathematical work, has been the numerical calculation. Nevertheless, the mathematical applications in Engineering require not only of numerical calculation, but rather an algebraic mixture of numerical calculations and manipulations on mathematical formulas. The symbolic calculation is indeed the technology specialized in the automatic manipulation of formulas, vectors, matrices, etc., with

numerical and/or symbolic elements. It is in this specialty where the use is especially useful from specialized software, as can be the packages of symbolic calculation Mathematica type [12], Maple [2], or Matlab [9]. These software packages have syntax easy to learn, since the orders and commands remember the mathematical operations that they execute and, therefore, its learning is fast and intuitive. In addition, the aid that offers these software packages is very complete and is informed with numerous examples. The University of Salamanca owns a license "Campus" for some of the versions of this mathematical software.

Mathematica is a system of computer algebra originally developed by Stephen Tungsten. It is also a powerful programming language that emulates manifolds paradigms using reescritura of terms. It uses code blocks (bookstores), to extend the capacities and to reorient the calculation. The programming language of Mathematica is based on re-writing of terms, and supports the use of functional programming and procedures (although generally, the functional programming is more efficient). It is implemented in a variant of the OO Programming language C, but the thickness of the extensive code of bookstores in fact is written in the Mathematica language, that can be used to extend the algebraic system [5].

Unlike other languages, like Maple or Matlab, Mathematica tries to use the transformation rules that know as much in every moment as it is possible, trying to reach a stable point. In a basic level, Mathematica can be used to realise numerical and symbolic calculations, as well as to realise graphical representations of functions. But in more advanced levels, it can also be used like programming language of great versatility to own built-in functions and instructions that in the traditional languages would require additional routines.

3. Collaborative Learning

One of the benefits of Collaborative Learning (CL) is that it allows learning by competences, in particular to use the power of the synthesis and analysis capacity, it allows to apply the knowledge to the practice and to the resolution of problems, as far as to adapt to new situations. Like tutors of the subject, we have the work to advise and to orient the students in the exposition of the subject, guaranteeing that the learning gets the formation wished for the student.

The activities that we proposed the students are the same suggested by David and Roger Johnson [11], to maintain interested students in classes:

1. To group the students in pairs. To provide four to five minutes to realise a collaborative activity that develops the knowledge about the presented subject. The intention of this activity is to provide the beginning with a discussion.
2. To give three or four minutes so that they discuss about the presented material. The discussion activity must give an answer to the propose question by the professor, offer a reaction to the theory, concepts or presented information and relate the new material to previous learning. The pairs must respond of the following way:
    a. each student formulates his answer
    b. it shares his answers with his companion, so that all at great length listen to the answer of their companion and form a new answer, better than the initial answers.
3. To select two or three students at random, so that they display summaries of his work or discussions.
4. To present another activity of discussion about the second part of the exhibition, during three or four minutes.
5. To repeat this sequence exhibition-discussion until the subject has been concluded.
6. To present/display a final activity of discussion that summarizes what they have learned of the subject. The students will have to have of four to five minutes to summarize and to discuss the material.

One of the requirement for an effectively structured cooperative lesson is that students believe that they "sink or swim together." Within cooperative learning situations, students have two responsibilities: 1) learn the assigned material, and 2) ensure that all members of the group learn the assigned material. The technical term for that dual responsibility is positive interdependence.

Positive interdependence exists when students perceive that they are linked with group mates in such a way that they cannot succeed unless their group mates do (and vice versa) and/or that they must coordinate their efforts with the efforts of their group mates to complete a task

The great advantage of the collaborative and cooperative learning in mathematical classes is that each student is an important part of their classmates learning process.

Conclusions

Activities developed with students - the use of mathematical software together with the group work - offer a much greater possibility for students to collaborate to make their learn active.

With these activities teachers make possible to teach students about the usefulness and importance of the new technologies and what is more interesting: how to use them in a work in their future career.

With this proposed work, that is done in groups, students learn how to applied the acquired knowledge and competences to a real problem, learning the use of new software at the same time.

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