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The cooperative learning: Understanding and increasing the knowledge of the facilities design without a professor extra effort

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Abstract

Lecturing has been prevailing in higher education. This teaching and learning model hinders the understanding of fundamental concepts in practical courses. The cooperative learning allows an improvement in the student's achievements, attitudes and persistence. The main goal of this work is to implement the cooperative learning in the teaching of the design of industrial facilities. This methodology aims to solve part of the problems of recently graduate students when they undertake engineering projects lacking knowledge. Finally, the results of an end-of-course satisfaction survey, conducted to assess this experience, are also presented.

Keywords

Cooperative learning; Distance learning; Peer Learning; Project-based learning

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1. Introduction

The main goal of a professor has always been to success in the fully knowledge transmission. This knowledge should be understood and it should remain in the students for a long time. The earliest ideas about how to transmit the information to be understood and kept in mind as long as possible were conceived as a cone (Dale 1946). The base represented the most firmly understood knowledge. Real experiences with a specific purpose are in the base and verbal communications are in the apex. So the model which warrantees a better comprehension is the one where the student receives the biggest audiovisual support[1]. This support has always depended on the era when it was being taught. However, it has always originated from a fundamental principle: our brain learns better if we practice cooperative learning. Primitively, the education was based mainly in cooperative learning with the family and the senior citizens (Luzuriaga 1977) but the increase of the knowledge caused the building of schools. One of the first methods was the dialogue-based learning (Socrates). In this method the teacher guided the students to discover the knowledge by means of lecturing, reflecting and questioning. In the Roman Empire, it was discovered that a person learns better when it teaches "Docendo discimus" (Seneca 64). Nowadays, the cooperative learning appears continuously. For example, in remote rural areas in India there are real evidences in which children discover the way to use a computer and to surf the Internet (Sugata et al. 2005).

On the other hand, a teaching and learning model based in the oral communication has been prevailing in the university. This model, consciously or unconsciously, has been penalizing the communication from the student to the professor. This problem is due to the enormous difference between the professor and the student's knowledge. Some-

[1] There are some studies where a memorizing percentage is added as a function of the support received (Chi et al. 1989) but some papers do not agree with this addition (Betrus and Januszewski 2002).

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times, the cause is the huge courses programs which force the professor to reduce this communication. Therefore, it has been a transition from a learning model where the student was the main part of the process to another model where the student plays a secondary role.

In addition, the courses programs have been enlarged with the help of audiovisual multimedia. So multimedia contents, instead of enforce the knowledge of the student, have been used wrongly to increase the contents of the subject. This practice can cause an unmotivated and bored set of students who listen to a professor teaching “a brilliant lecture”. In this situation, the best students can keep some concepts in their short-term memory (as it has its limits), then they memorize the rest and, finally, they can solve the problems introduced by the teacher. The teacher has not to intervene and they pass the subject with some effort. But the real question is: Do they understand the underlying concepts? Do they know how to resolve another type of problems? The answer is: they learn but they have conceptual failures which prevent them to solve problems whose formulation is different to the usual one (Halloun and Hestenes, 1985a). This fact, confirmed by other authors (Halloun and Hestenes, 1985b; Mazur 1992), has brought us to a conclusion: “it is difficult to learn in the university because the students do not collaborate in their study” (Smith 1998). Therefore, it is very important that students practice cooperative learning, not only in their own study (Chickering and Gamson 1987) but also with their professors and classmates.

One of the most significant examples among all the collaborative learning working groups existing in Spain, are the interactive ones (Aubert et al. 2000; Aubert et al. 2008; Castells et al. 1994; Flecha et al. 1977; Flecha 1997). These are groups of students, fathers and teachers who talk among peers improving the results, the persistence and the attitudes of the students (Springer et al. 1999). These groups make them responsible of their own and their peers learning process (Michaelsen et al. 2003; Paris and Turner,

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1994; Weimer, 2002). The first student, who understands a concept, improves his knowledge teaching his peers. The peers understand the concepts in a better way because they receive explanations from a person who has just created the strategies to comprehend them. So they prevent the invisible barrier of the vast amount of knowledge of the professors, they allow to reduce the student work, improve the comprehension and allow to work transversally another abilities (problem solving, working in groups, leadership ability, project management, capacity to analyze the peers work, capacity to resolve conflicts in a group and organization) (Sheetz 1995; Winchester-Seeto 2002).

On the other hand, the university teaching is very specific, with tools for the big groups (Davis 1993; Lewis 1994; McKeachie 2006). Nevertheless, it is very difficult to work with reduced groups in massive attended lecture halls. This problem could be solved with the help of assistant professors, teaching monitors (Nyquist et al. 1991), or dividing the groups (MacGregor et al. 2000; Michaelsen 1983; Stanly et al. 2002). However this is not possible in the Spanish Universities, so we have to apply another techniques developed in other universities. In the University of Harvard, the professor teaches asking and does not lecture. This technique is called peer instruction or peer learning (Mazur 1997; Crouch 1998; Crouch and Mazur 2001). The student, previous to the class, has to read a text and to answer a set of questions online. The professor reads the results and prepares himself to introduce the problematic concepts in the following session. Then he reinforces those concepts and asks new questions during the lecture. If the percentage of successful answered questions is higher than 70% he continues introducing new concepts but if this percentage is between 30% and 70% he lets a few minutes for the students to talk each other about these answers. The collaborative learning appears in this moment because some students have just solved his difficulties assimilating a concept and can teach their peers how they did it. Many students understand the con-

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cept, improving the percentage of correct answers (Ogawa and Wilkinson 1997; Saye 1997; Redish 2003) and this improves the professorship quality (Jackson and Bruegmann, 2009).

The objective of this paper is to put in practice the best of the mentioned methodologies (lecturing, project-based learning and cooperative learning) in the teaching process of the design and measure of industrial facilities for a student body of more than one hundred students.

2. Current situation and problem statement

The subject object of our study is “Industrial and Commercial Installations II”. It is taught in the third course of the degrees of Industrial Engineering in the University of Extremadura. In a semester the students have to learn the knowledge of a wide range of facilities starting from a generic base where they do not know the basic components of a facility. We have 140 students divided into three activity groups. These groups are further divided in small groups of 20-30 students for laboratory classes.

The program of the subject is very long with directed laboratory practices where the students only have to follow a provided guide. They do not need to justify the selected option and they run commercial software, easy to use without the possibility for multiple changes. The practices are not specific and do not allow to check if a student has acquired the necessary skills. The consequence is that the students gain a quite general knowledge but do not have the ability to calculate and to accomplish a specific project.

The main goal of the present work was to apply collaborative learning in this subject, to establish a bridge with a fourth course subject (entitled Projects) and to increase the program of the subject to the specific projects. Thus the students can understand the calculations required by an industrial installation and they gain new abilities (Yedidia et

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al. 2000). These abilities were roughly and transversely learned by the graduates in previous years. The activity was designed in a way both professors and students did not take on an enormous extra work. The students were compensated for the effort these kinds of experiences require. The activity was atemporal and was not limited to a specific lecture hall. The necessary material was available through the virtual campus of the subject. The only spatial and temporal limitations were the weekly supervision meetings of the different tasks imposed by the professors.

3. Learning methodology

The methodology is mainly based in project-based learning, combining lecturing and the peer instruction. The developed activity is to measure a specific hydraulic facility. It was introduced in the first class the professor attended the students and it was limited to the first thirty students enrolled. These students were divided into five groups and were free to attend the laboratory classes as a compensation for the extra work. However the professors recommend them to attend these classes to learn the knowledge taught there. Each project corresponded to a different installation (Hotel, housing block, residential area, sporting arena and swimming pool). The professors granted one point out of ten for the students involved if the project was calculated and presented successfully[2]. The students received a short and very specific task each week. The schedule for the different tasks was:

[2] There are recent references where the students, who collaborate teaching other students, receive recommendation letters (Downing and Liu 2012).

1st week: The professor introduces the work to be done and give to each group a blueprint of one facility. Task: Design a CAD pipe network with adequate pipe lengths for each section (Figure 1).

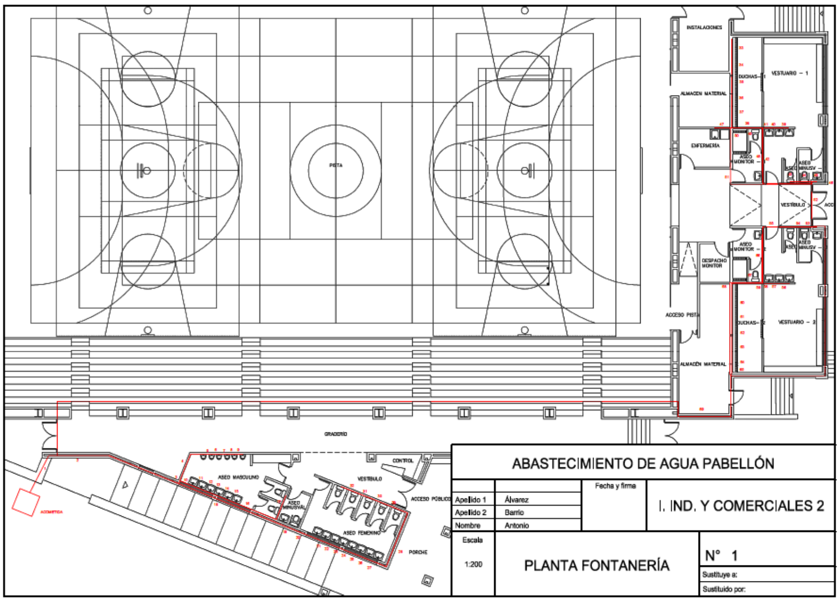

***Figure 1**. CAD Design of a pipe network in a sporting arena*

2nd week: The professor checks the different blueprints. Task: To create a spreadsheet (Figure 2) with the minimum flow rate for each pipe. The flow rate has to be calculated according with the current regulations for each device.

3rd week: The professor looks over the different spreadsheets. Task: To calculate the simultaneous flow rates in groups of different devices.

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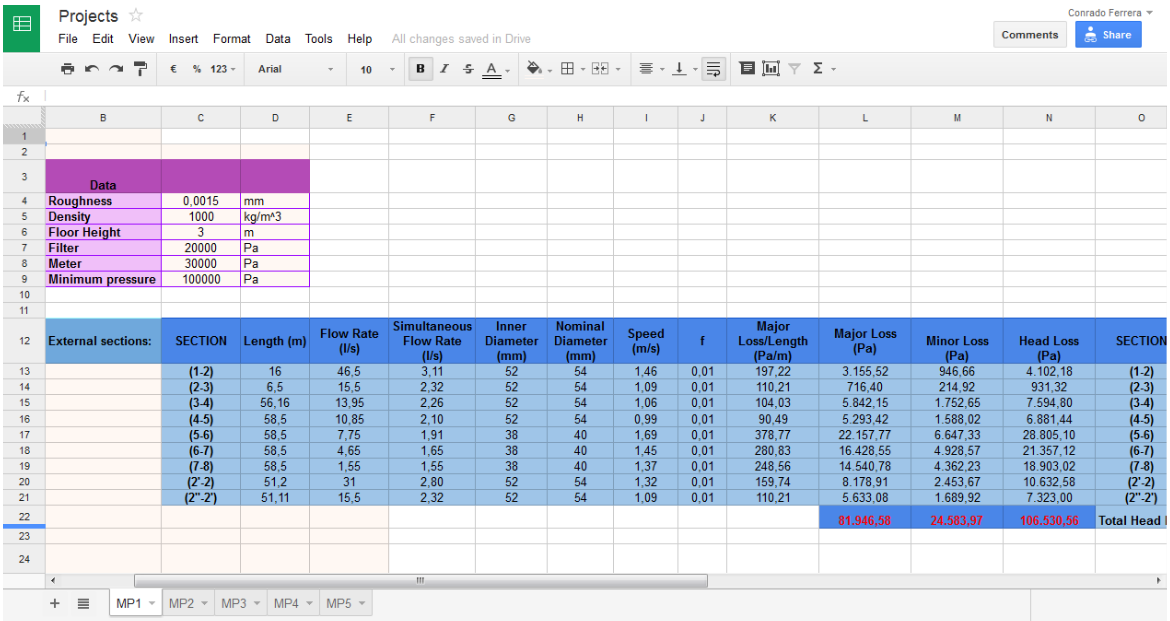
4th week: To inspection previous work and to explain the concept of maximum water speed in pipes. Task: Calculate the inner and the nominal diameter of the pipes to accomplish the requirements of the current regulations.

5th week: The professor checks the diameters of the pipes. Task: Evaluate the head loss in pipes and the minor losses.

6th week: The professor teaches the need of a pressure group. Task: The students rest this week.

7th week: To finish the projects.



Data		
Roughness	0,0015	mm
Density	1000	kg/m^3
Floor Height	3	m
Filter	20000	Pa
Meter	30000	Pa
Minimum pressure	100000	Pa

External sections:	SECTION	Length (m)	Flow Rate (l/s)	Simultaneous Flow Rate (l/s)	Inner Diameter (mm)	Nominal Diameter (mm)	Speed (m/s)	f	Major Loss/Length (Pa/m)	Major Loss (Pa)	Minor Loss (Pa)	Head Loss (Pa)	SECTION
	(1-2)	16	46,5	3,11	52	54	1,46	0,01	197,22	3.155,52	946,66	4.102,18	(1-2)
	(2-3)	6,5	15,5	2,32	52	54	1,09	0,01	110,21	716,40	214,92	931,32	(2-3)
	(3-4)	56,16	13,95	2,26	52	54	1,06	0,01	104,03	5.842,15	1.752,65	7.594,80	(3-4)
	(4-5)	58,5	10,85	2,10	52	54	0,99	0,01	90,49	5.293,42	1.588,02	6.881,44	(4-5)
	(5-6)	58,5	7,75	1,91	38	40	1,69	0,01	378,77	22.157,77	6.647,33	28.805,10	(5-6)
	(6-7)	58,5	4,65	1,65	38	40	1,45	0,01	280,83	16.428,55	4.928,57	21.357,12	(6-7)
	(7-8)	58,5	1,55	1,55	38	40	1,37	0,01	248,56	14.540,78	4.362,23	18.903,02	(7-8)
	(2'-2)	51,2	31	2,80	52	54	1,32	0,01	159,74	8.178,91	2.453,67	10.632,58	(2'-2)
	(2''-2')	51,11	15,5	2,32	52	54	1,09	0,01	110,21	5.633,08	1.689,92	7.323,00	(2''-2')
										81.946,58	24.583,97	106.530,56	Total Head

Figure 2. Example of the shared spreadsheet

The professor lectures the students the first three weeks in the computer lab. The attendance is mandatory. After the third week of instruction, the groups receive technical assistance during the office hours. The different spreadsheets are shared in Google Drive (Figure 2). This is a useful tool for both the professor and the students. They can do different changes and the professor could check them and solve the doubts. The students' activity developed into a project-base activity in the last weeks. They started to confront their ideas showing different alternatives to the calculations made, improvements, errors, etc.

After a first phase based in lecturing and project-based learning, a second phase started. In this phase the main objective was to transmit all the knowledges to the rest of the class (110 additional students). Our idea was to apply peer learning. The students involved in these projects taught the rest of the class with a very slight supervision of the professor. We freed them to explain the knowledge in their own way. So they not only publicly demonstrate them they have the knowledge to measure an industrial facility but also help the professors in the learning process of the class.

This phase was performed in the context of a short general discussion session. The format of this meeting is lecturing and dialogue between students. A speaker was elected in each group. The selected speakers prepared an oral presentation. The presentation allowed them to teach the rest of the class the different steps associated with the development of any hydraulic system. The teacher reviewed the presentation content before the public exhibition. We would like to mention that the preparation to the content was fully agreed between the professor and the selected students. Everybody had to reason the importance of introducing or deleting a concept. For this reason, some different concepts, the teacher had given for granted, were preserved at their request. The remaining members of the group made a poster (Figure 3). Its cost was covered by a programme to strength the EHEA in the University of Extremadura. The use of posters came to fill gaps in the oral presentation, and allowed us to observe particular details untreated during exposure. The students helped their classmates with unresolved questions that had appeared during the oral presentation. The great majority of the questions were resolved by them without teacher involvement. This showed us the total assimilation of the concepts and the work done. Besides, the students, who did not participate, asked all kinds

of questions. They were interested in calculating the facility and rated positively the work of their peers.

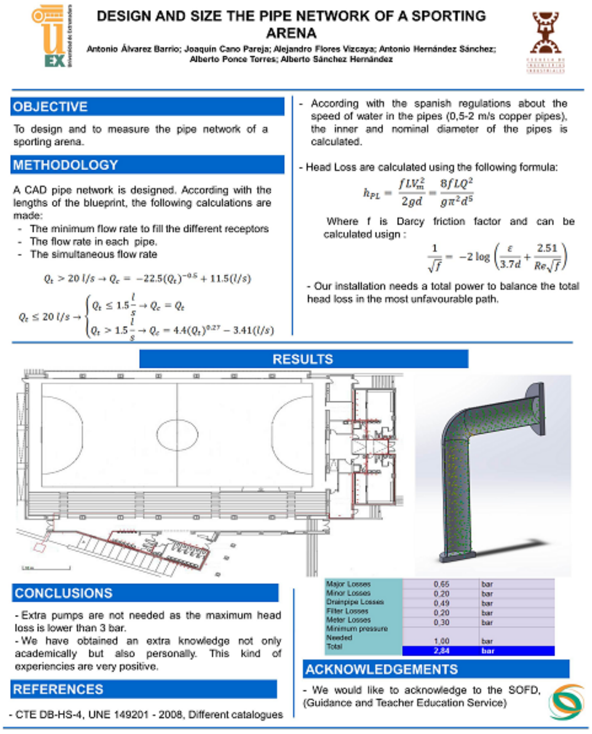


Figure 3. Image of one of the posters made

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4. Results

The students have learned to analyze, synthesize and manage technical information provided by the professors. They have solved a complex problem in an autonomous way with a slight supervision of the teacher. Working in groups has allowed them to develop interpersonal skills such as to discuss between equals, to tolerate mistakes and to criticize constructively their peers with the support of the analysis of the data, the results of their classmates and other sources. The rivalry between groups has encouraged them to give the best of themselves, which has resulted in an improvement in the quality of work and an increment in their knowledge. Moreover, they have begun to speak in public.

All the aforementioned has been done by using public domain or free software for students. They have been able to find, to select and to use appropriate calculation tools for projects.

Finally a satisfaction suvey (Figure 4) was conducted between the participating students in order to get their about how this teaching methodology was performed. The survey consisted of eleven questions, which are shown in the final appendix of this article, with five possible answers (none, little, some, quite a lot) to each one of them. Additionally a web form is added to save suggestions for improvement and to include possible errors. Over 88% believe that the difficulty level and the methodology are quite or very adequate. The same percentage is satisfied with the additional point given to the task (questions 1, 5 and 7). All the students considered that weekly and group supervision is correct (questions 2 and 3). They also rate positively the extra formation received (question 6). A 60% report that the time spent on homework is excessive (question 4), so they propose that the initial blueprints are delivered in the format of the graphic design tool with which they work. They are demanding more information at the subject website to

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reduce the number of visits to the teacher. This is quite contradictory, since 88% shows that it is useful to start from scratch in the project (Question 9). In addition, the experience in the first two sessions, where freedom for calculations was given, showed us the huge majority of students preferred a personal assistance. They also propose other conflicting solutions, such as decreasing the number of components in the group, so they would have to do more work. Regarding the explanation to other students, more than 75% considered the method effective. On the desirability of this methodology remains in the future, over 88% expressed should be done with all the subjects of the degree.

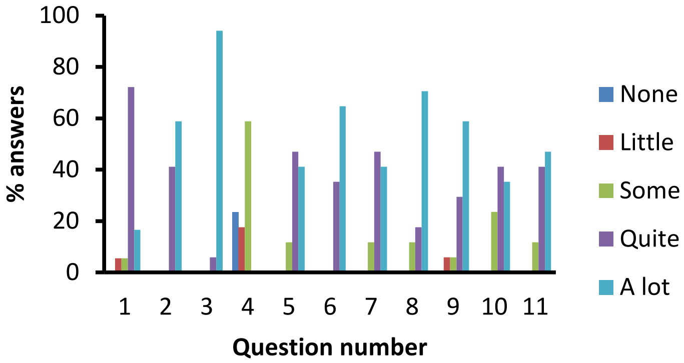

Figure 4. Survey results

5. Conclusions

A mixed methodology between lecturing, project-based learning and cooperative learning on teaching projects of industrial facilities has been implemented for over a hundred students. It has been found that the practices may no longer be over-managed and can be closer to the reality of the engineers. The completion of this work reveals the creativity

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of students. The use of free software, a virtual campus with accurate information and a weekly meeting with each group is enough to guide their work and not to overload the teacher. It is important to reward the extra temporary effort undertaken by the students when put up experiences like this. Experience has shown the student satisfaction, who wants this activity to be extended to other subjects.

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APPENDIX

Satisfaction survey of this methodology

1. Is correct the difficulty level?
2. Do you agree with the weekly supervision in the lecture hall/professor's office?
3. Is correct the supervision of the different groups separately?
4. Do you consider excessive the time spent in this work?
5. Are you satisfied with the extra point?
6. Do you find useful the extra formation received?
7. Is correct the methodology applied?
8. Are you interested into extend this kind of practices to the rest of this subject?
9. Is it useful to start from scratch the project design?
10. Do you believe that to create presentation/posters is an effective way to transmit all the knowledge learned to the rest of the students?
11. Are you interested into extend this kind of activities to different subjects in the degree?
Could you write down any suggestions to improve or to correct errors?