Cooperative Learning to Lighting Design Using Renewal Photovoltaic's Energy

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***Abstract*-This work presents a case study of the use of information and communication technologies (ICT) as part of the promotion of cooperative learning supported by computer in exterior lighting design, with solar energy. The influence and importance of ICT in various aspects, among which is the field of education, is already a subject practically defined and accepted. In this context the cooperative learning, including ICT, gives rise to the research area called cooperative learning supported by computer (CSCL). This study indicates the effectiveness of Problem Based Learning (PBL) in educating engineering students to make students more responsible in the contents area as well as in generic competences. By using PBL students get the opportunity to work or simulate real problems, making the learning experience much more meaningful. This method can also be seen as a benefit for Electrical Engineering programme where educators strive for improved teaching and learning.**

***Index Terms*-- cooperative learning, information and communication technologies, lighting project, photovoltaic's energy.**

I. INTRODUCTION

In Higher Education Institutions (HEI) the use of models to teaching flexibilize and adjustable to the student learning style allow equal opportunity in entrance to higher education among students with different time availability. Currently, the implementation of new pedagogical models is a real challenge for HEI to integrate students, with distinct requirements, mainly motivated by their professional situation [1-4].

Future engineers must be taught to be creative and flexible, interested and imaginative too. There should be a meticulous attention on team work and on the challenges of sustainable development, including cultural, economic, environmental and social imperatives. Future engineering curriculum should be built around developing and increasing skills and not only technical knowledge.

The motivation to the introduction of the model of project-based learning (PBL) in engineering was mainly the consequence of the many demands acknowledged from employers and HEI. Regardless of the many years of study, in terms of knowledge, skills and attitude, many former students may still demonstrate a lack of requirements fundamental to the industry.

PBL is an idea and not necessarily a technique. It is very important to train students to master the crucial aspects of effective communication, deep understanding, and analytical thinking and other knowledge and values that they may require [5-8].

Many national HEI are adopting Information and Communication Technologies (ICTs) to support teaching methods, making them, at the same time, more flexible and adaptable to students' profile and expectations. However, PBL is still far from being a constant methodology in undergraduate courses offered by HEI. All these institutions have developed or supported PBL pilot projects or similar education methodologies. In the Department of Electrical Engineering (DEE) of "Instituto Superior de Engenharia de Coimbra (ISEC)" there are teaching and training continuing efforts to make available academic programs that are alert to the labour market and oriented, through learning, to produce well-trained professionals who will be the dynamic forces for a sustainable development.

The DEE, being aware of the advantages that such a methodology may bring to the teaching/learning process, and wanting to give a positive contribution to the school's mission, supported the project that is presented here.

One of the purposes of this project was to enable students to design an external lighting project to meet a requirement of the community. Different projects were assigned to all teams. The real problem that was proposed covers most of the contents of this course (indoors and outdoors lighting). Groups of three students performed the task but each team member was given specific assignments towards a common goal. The resources were divided into topics, so that each team member had part of the information necessary to complete the proposed task. Each team member was assigned a specific task within the group, using the necessary analysis and studies of lighting project design in order to achieve the main objective. The students were presented with a virtual scenario, quite similar to the real world, where they were required to perform as if they were in a real life situation. One solution was to use a photovoltaic's renewal energy to implement an efficient illumination project. With the development of technology not only have students' learning methods switched from practicing on blackboards to the internet but also their learning goals have changed from knowledge-absorber to problem-solver. This paper illustrates how the module of Lighting Design Project, in the DEE, engaged students in the use of PBL. This module requires

previous learning experience and an amount of background knowledge. Students need to be motivated and encouraged to become responsible for their own learning. The final evaluation of the students was divided between demonstration of skills and understanding of course contents. The purpose was to develop imaginative and persuasive proposals for changes in education for professional practice.

Tiong et al. [8] proposed the following goals for PBL:

1. Application, creation and critical thinking;
2. Improving communication skills;
3. Enhancing cooperative learning ability;
4. Developing the ability to explore oneself and be responsible for oneself;
5. Enhancing the ability to apply and look for knowledge;
6. Enhancing the planning and controlling ability for students.

The design of PBL is based on the practical and theoretical needs to motivate learners and guide them to understand, apply and create knowledge; furthermore, learners can understand information or construct new models through passed experience, case study or knowledge sharing [8].

The projects are intended as objectives in a problem-based approach to learning and reflect the complexity of problems in sustainable development as they impact on the practice of professional science and engineering. The idea is that the student responsibility can be compared to the one of a young graduate engineer in industry.

This paper presents the work done in the course of Electric Power Systems Project (EPSP) of the Electrical Engineering course, in which the methodology was carried out. Below are the objectives of the curricular unit of EPSP (Lighting topic) that supported the PBL strategy implementation. EPSP is a unit of the second semester of the third year of the Bachelor's in Electrical Engineering. This curriculum unit aims to provide students with knowledge to conceive, model, analyse and design external lighting systems.

The class had twenty-seven students, divided into nine groups of three. At the end of this curriculum unit, each student should have a solid and fully updated reference framework of lighting systems, in which the relationship between lighting technologies and the real world, competition and competitiveness, gain new dimensions and shape.

This case study also describes the experience of two teachers with their class along a semester using computer aided technology for instruction and assessment. The most important part of PBL is a suitable problem which comes from the real world and has a relationship with the course.

II. Teaching And Learning Approach

There was a general discussion of the process of PBL as a resource for developing competences and skills in relation to sustainable development in engineering. The effect of this analysis was that several aspects such as the professional competence profile, the program structure and the instructional strategies were considered to be altered in the new curriculum.

The module of EPSP (Lighting topic) was chosen to study the effect of using these Active Teaching Strategies. These strategies are instructional methods that engage students in the learning practice. The most important factor of active learning is student activity and engagement in the learning process. The use of these techniques in the classroom is fundamental because of their powerful impact upon students' learning [9-10]. Active learning is a teaching method that works in engineering. Active learning contrasts with the traditional lecture where students passively receive information from the teachers [7]. One major issue, in using these strategies, is to change the responsibility of the teacher that must be well-informed in alternative techniques for questioning and discussion and be capable to create a encouraging intellectual environment that encourages students to take risks.

It is expected that the project work allows students to look into a problem, classify and divide it into its essential parts and perceive the knowledge required to be used in a new context. They have to make use of an interdisciplinary approach to describe the solution for electrical design problems. They must show ability to plan and control the different stages and progress of group work. To resolve engineering problems we must begin by using the method of 'thinking and outlining the process to reach a solution'.

Along the project, students worked in teams of three to develop the desired learning skills, motivation and assessment. PBL is a dynamic process in which the students work in teams accomplishing a common goal. The whole class (27 students) was supervised by two teachers. All teams had access to experimental, testing as well as computing facilities.

Throughout the semester, four teams of students were expected to learn the design of the required project; to do the research and the evaluation of the Lighting Design project of EPSP (Lighting topic); to perform the study of the Lighting Design using the Dialux 4.3 software package [11]; to make the analysis and determine the most suitable methodology and prepare the presentation and the documentation of the project.

III. Case Study

The main objective of this work was to analyse the technical and economic feasibility to implement an exterior lighting system efficient and sustainable for the campus of ISEC.

One of the requirements of the project was the preparation of a schematic produced through software Dialux 4.3. Photovoltaic equipment, "*Gira Sol*" (sun flower), was choosen to power that infrastructure. An illustration of the before and after implementation of equipment through photos taken on the ground and images developed with the software Dialux 4.3 was made to illustrate, to some extent, the difference found through this implementation [11]. The equipment for outdoor lighting is much damaged at the existing level of maintenance. It was found that many of the lights were broken or rendered or some are hidden by trees,

leaving the surrounding area without any kind of lighting at all. Fig. 1 illustrates the campus of ISEC with the 33 poles position.

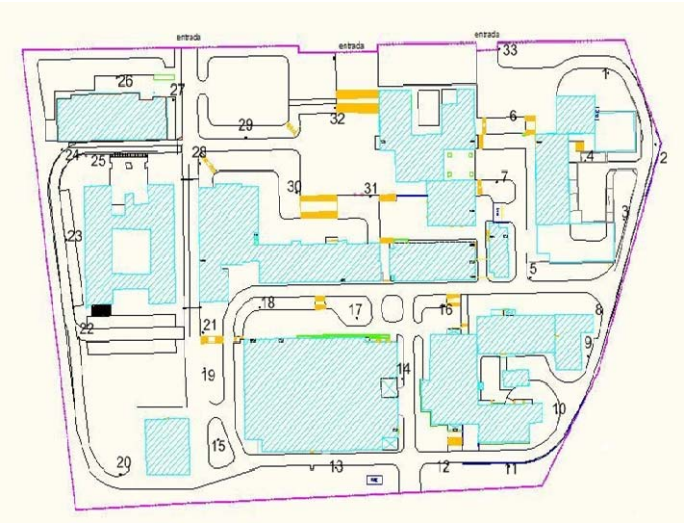

Fig. 1. Campus of ISEC with poles position

Table I presents the values obtained with the equipment and the registrations of the exterior light system.

TABLE I

VALUES IN LUX OF ILLUMINATION POLES POSITIONS

Measure Points	1	2	3	4	5	6	7	8	9	10	11
Values (lux)	30	13	13	0	57	47	47	18	13	16	0

Measure Points	12	13	14	15	16	17	18	19	20	21	22
Values (lux)	0	26	9	0	63	67	44	0	0	24	27

Measure Points	23	24	25	26	27	28	29	30	31	32	33
Values (lux)	26	20	20	49	22	63	47	65	45	47	0

The mean value of the luminance, in this case was:

$$E_{med}=27.82\ Lux$$

As it can be demonstrated, the E_{med} value obtained is quite low since the minimum value required for the illumination of public places is 50 Lux.

Fig. 2. Civil department of ISEC

Fig. 2. Civil department of ISEC (cont.)

Fig. 3. Physic and Mathematic departments of ISEC

Fig. 4. Campus of ISEC with traditional poles

Fig. 5. *Gira Sol* Equipment

For the development of this work was carried out a wide survey on core businesses of renewable energy, Solar Photovoltaic through Panels.

The *Gira Sol* uses photovoltaic technology for power generation (Fig. 5). During the day the photovoltaic panels transform solar energy absorbed into electrical energy. The electrical energy generated by photovoltaic panels is stored in batteries for later use during the night. A controller controls the loading and unloading of the battery for consequent maintenance, program operating regimes of the lamp and monitors the energy balance of the system. *Gira Sol* is powered by solar energy, does not need electricity allowing huge savings in infrastructure construction. *Gira Sol* has the ability to make an adjustment of the amount of light emitted by the lamp through a pre-programming and adjust automatically the illumination level depending on the time of the year and the needs of the place to illuminate [13]. The *Gira Sol* lamp uses the sun as the only source of energy, a renewable and clean energy. The bills paid by ISEC during four months (September, October, November and December of the year 2008), presented an annual average value exceeding 100,000 €. As shown in Table II, the total investment in equipment was 142,447.58 €. The amount spent will be recovered after approximately 12 and half years. The value of the investment can be culled substantially, because this type of equipment is covered by subsidies of the Portuguese State and thus ISEC may reduce the burden of supporting its implementation.

TABEL II

INVESTMENT CALCULATIONS AND RETURN

Costs	***Unit price S/iva***	***Unit price C/iva***	***Totals***
Gira Sol Kit	2.951,18 €	3.305,32 €	132.212,86 €
Transport	30 €	36,30 €	36,30 €
Fastening Material	44,52 €	53,87 €	2.154,77 €
Labour	100 €	121,00 €	4.840,00 €
Crane rental for unloading/Assembly	400 €	484,00 €	1.452,00 €
Hire of back-hoe	455,00 €	550,55 €	1.651,65 €
Fuel	----	100 €	100 €
		Total investment	142.447,58 €

Amount of Poles to install	40	
Work days	3	
No hours per year that are connected to the exterior lights	4015	
Total Expense of electricity per year	114.365,7 €	
External electricity Expenses per year (*)	11.436,57 €	
Time to return on investment	12,46	Years

(*) Assuming 10% of total annual electricity invoice

IV. DISCUSSIONS AND CONCLUSIONS

This work presents a case study of the use of information and communication technologies (ICT) as part of the promotion of cooperative learning supported by computer in lighting design, with solar energy. The influence and importance of the introduction of information and communication technologies (ICT) in various aspects, among which is the field of education, is already a subject practically defined and accepted. In this context the cooperative learning, including ICT, gives rise to the search area called cooperative learning supported by computer (CSCL). One of the purposes of this project was to enable students to design an external lighting project to meet a requirement of the community. Different projects were assigned to all teams. The real problem that was proposed covers most of the contents of this course (lighting). Groups of three students performed the task but each team member was given specific assignments towards a common goal. The resources were divided into topics so that each team member had part of the information necessary to complete the proposed task. Each team member was assigned a specific task within the group, using the necessary analysis and studies of lighting project design in order to achieve the main objective.

The Laboratório de Investigação e Inovação Tecnológica (Laboratory of Research and Technological Innovation) of ISEC (LIIT/ISEC) provided the laboratory learning and allowed the development of experimental skills, facilitating the ability of students to work in teams, to communicate effectively, to learn from mistakes as well as to be

responsible for their own results. Because of the costs involved, virtual instruments were used, through computer simulations, to experiment practical, real life situations. From the students' point of view, the laboratory became really attractive and useful to learn about lighting theory.

The students are presented with a virtual scenario, quite similar to the real world, where they are required to perform as they would in a real life situation. The solution was to use a photovoltaic's renewal energy to implement an efficient illumination.

The lamp solar *Gira Sol* (rotates with the sun) was the response to the challenge. *Gira Sol* is powered by solar energy, does not need electricity allowing ~~a~~ huge savings in construction of electrical infrastructure. The *Gira Sol* lamp uses the sun as the only source of energy, a renewable and clean energy.

The project submitted aroused the curiosity of students to learn more and this resulted in the development of new ideas and the attempt to find solutions to the problem with the help of the software provided. There have been many debates and discussion sessions through which students, within and among the different groups, were able to exchange relevant information and ideas that were useful for the completion of their projects. Students also improved their capacity to study by conducting research in the library, making references, extracting information and, through simulations, have also been exposed to the future labour market and real life.

The PBL methodology was a method with a strong component of self-study. This approach allows the customization of the learning speed and time management. The student is at the centre of the all process, having the central role, being in charge of his/her learning, but with the intervening support of asynchronous sessions that place him/her nearer to the system, and provide the management and incentive for future challenges [12]. The method adopted – PBL – proved suitable to students' profile and correct to the objectives of the curricular unit. The existence of the PBL option has revealed an increment in the success rate in the curricular unit of EPSP. With this type of equipment ISEC may have a fully sustainable lighting outside, and also contribute to a cleaner environment.

The evaluation was based on the merits and qualities obtained in view of the nature of the project, the solution proposed for each problem, as well as aspects of originality in their presentation. At the end of the semester the students got better grades when compared with the previous school year, when PBL had not yet been applied.

The conclusions of this study were encouraging both on the part of teachers and students. The results show that students have benefited from the experience of actually working as members of a team in relation to learning using conventional classes.

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