The Renewable Energy course at the Technical Engineering School of Barcelona (EUETIB/UPC)

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Abstract

A "Renewable Energy Course" has been offered for several years at the Technical Engineering School of Barcelona (EUETIB). This paper reports on our experience as teachers of the "Renewable Energy Course". The course program and its methodology are also described.

The main objectives of the course "Renewable Energy " are to allow engineering students to learn fundamentals and essentials on Renewable Energy, the present situation on Renewable Energy in Catalonia and what kinds of renewable energy are basically used in Barcelona. Due to "Ordenança Municipal de Medi Ambient Urbà" we decided pay attention especially on Solar Domestic Hot Water Systems (SDHWS).

The aim of our paper is to share our experience on:

- What kind of knowledge we considered the most reasonable for a course on renewable energy.
- What kind of methodology we used during the course.

Key words:

Project Based Learning, Study Group Work, Solar domestic hot water systems, Photovoltaic solar home systems, Barcelona's renewable energy policy.

1. Course Origins.

The "Renewable Energy Course" has been offered at the Technical Engineering School of Barcelona (EUETIB) since 1999. In the beginnings of the course master class methodology was used in order to reach theoretical objectives.

The main course objective was to provide students an overall view of the renewable energy, and so, to go more deeply into different types of renewable energy was really delicate.

Theoretical objectives were developed in four areas, these areas were:

1. Basic concepts: this section must be introduced due of the diverse students' formation. Basic thermodynamics' principles were though. As example:
    a. Energy definition.
    b. Units and symbols.
    c. Renewable energy definition.
    d. Energy efficiency definition.
    e. Heat transfer.
2. Renewable energy: when students were conscious about energy's basic principles, basic essentials on renewable energy were introduced. So we described different types of renewable energy and their technical solutions, as example:
    a. Solar Energy.
        i. Photovoltaic.
        ii. Solar water heating.
        iii. Solar air heating.
        iv. Passive solar heating.
    b. Wind energy.
    c. Small hydro.
    d. Biomass heating.
    e. Ground-source heat pump.
3. Energy saving: in this point we tried to emphasize the importance of our attitude and behaviour day in day out relating to energy saving.
4. Project analysis: very briefly, the most relevant aspects in a project analysis were introduced about the:
    a. Solar energy.
        i. Photovoltaic.
        ii. Solar water heating.
        iii. Passive solar energy.
    b. Wind energy.
    c. Small hydro.
    d. Biomass heating.

Across the years we could compile information about the most relevant aspects of the course, by means of this information we reached the following summarize conclusions:

- The length of program did not allow students to deal with topic in depth investigation.

- Project analysis was the most interesting area for all students.
- The most of students did not reach desired result.

2. Introduction

In order to improve course's result we started a change process. Master class methodology did not allow student to be motivated to work towards objective's course, maybe because encourage a passive attitude, or maybe because of the diverse student's formation.

Our experience and results on the other "Renewable Energy" courses showed us that theoretical approach doesn't result efficient. So we assume that a new methodology could be the solution in order to obtain better results.

We decided then to introduce the Project Based Learning methodology (PBL) in order to improve knowledge about renewable energy and students' attitude during the course. We wanted that the educational philosophy applied in the course:

- Increase motivation.
- Increase course effectiveness.
- Introduce students in group study philosophy.

So it was necessary to reconsider the way to work with list of topic's contents.

We accepted the fact that the initial four areas were essential in our course, so we decided to change their order. We were convinced that "Basic concepts" and "Renewable energy's basic principles", because its low level difficulty, must be delivered to students so they could study it by their own.

Due the current situation on Renewable Energy in Catalonia and Barcelona's renewable energy policy, to possess knowledge on Renewable Energy, especially Solar Domestic Hot Water Systems, is being more and more useful for a new engineer students. So we decided to pay special attention to solar energy in the new course direction.

In the early days of the course we gave to students a CD-ROM. In the CD they could find information about the course, solar energy course's books, state and local legislation, articles and solar energy projects. We choose one of these projects as students reference guide. We decided to use a SDHWS project analysis finished because the short length of the course did not allow students to realize one by their selves.

We knew that most students did not have solar energy background for understanding the project's calculus process, but the capability to determine what kind of concepts they need for.

The reasons to give them a project were:

- To introduce basics concepts in solar domestic hot water systems.
- To expose students to real-work applications in solar energy.
- To teach the way to legalize solar domestic hot water systems in the city of Barcelona.

3. Course Objectives

To develop learning in the cognitive and the affective domain was the main course objective for us. Usually when course objectives are drawing up only cognitive domain is take into consideration. Obviously, knowledge, skills, understanding and "know-how", are every relevant in order to create a good course. It is true that we must deliver information to students to be memorized, help them to develop skills in order to understand how a project could be done and finally check their results, but we can forget that learning in the "affective domain" is also important. In fact attitudes and values play as important a part as aspects of the cognitive domain.

Around these premise we defined as generic course objective to show students their capability to realize and develop a self learning process in the renewable energy area, and by means of this self learning process they must understand how a solar domestic hot water system is calculated and legalized in the city of Barcelona.

In order to achieve the objectives related to the affective domain students must:

- Know how and where to get renewable energy information, especially on SDHWS.
- Know to carry out the work planning of self learning process.
- Develop course specific objectives to make self learning process easy.
- Work whit the specific objectives defined as a working tool for:
    - Clarifying what kind of work to do.
    - Planning course tasks correctly.
    - Verifying their self learning progress.
- Evaluate work from the specific objectives consecution.
- Get to know work group dynamics, their main advantages and disadvantages.

With reference to the objectives related to the cognitive domain we were aware of the main objective course. If we really want to show students their capability to develop a self learning process these kinds of objectives must lead them on the right track. For this reason four cognitive objectives were defined as secondary objectives areas. These objectives areas are:

1. Renewable Energy: The students have to be able to know about existence of different types of renewable energy. This area is equivalent to former areas "Basic concepts" and "Renewable energy" used in the previous methodology.
2. Solar Domestic Hot Water Systems: In order to understand the basic principles of these systems students almost has to identify parts of the system and know how these parts work.
3. Solar water heating project analysis: assuming knowledge on solar domestic hot water system,

students have to able to know how to make the first move in project analysis process.

4. Legalization process: As a final target, an overall vision about how to legalize SDHWS is expected.

4. Pedagogical Methodology

In order to achieve the main objective we decided to introduce PBL methodology. When we took this decision we were conscious of two great difficulties.

- First difficulty: course time limit.
- Second difficulty: students' resistance about PBL methodology.

In order to mitigate first difficulty a solar water heating project analysis was delivered. By means of the project results students could become more familiar about their needs in the project analysis process. From this point we tried to follow the development of PBL methodology, that is, students must:

- Evaluate their knowledge and their need for increasing this one.
- Draw up a self learning process where contents and how to organize their time were equal significant.
- Evaluate self learning planning results about project needs in order to improve process quality.

We described PBL methodology during the first days to break students' resistance. Advantages of PBL methodology were emphasized and also teacher and students' role were explained. So at the end of these days students' work teams were formed and course information could be delivered.

All Information was delivered in CD-Rom format. Different folders were created to contain different information. Six folders made up CD framework:

- Articles' folder: recent articles about renewable energy were considered interesting for students training. As articles examples, designs procedures, control problems, renewable energy subsidization policies,…
- Course document's folder: guidelines, methodology explanation and bibliography were necessary to be delivered in order to make easier students' work.
- Book's folder: in this folder students could find several books about basics on renewable energy and solar energy (photovoltaic and solar water heating).
- Governmental documents' folder: city council, autonomous government and central government regulations are absolutely necessary in project analysis. Trough SDHWS project analysis delivered students had to be able to connect project analysis and legal procedure.
- Materials and manufacturers' folder: in this folder they could find all sort of information about manufacturers and their range of products. Technical specifications are essential in order to develop SDHWS project analysis.
- Projects analysis' folder: several photovoltaic and SDHWS projects were delivered as guideline in project analysis.

Then, in no time at all, began the real students work. The first step was to choose one of the several SDHWS analysis projects for all groups. By means of this project all groups would be evaluated. This evaluation would be done in four different phases related to four different areas of knowledge, renewable energy, SDHWS, solar water heating project analysis and legalization process.

In each evaluation phase students had to:

- Develop and write, by means all sort of information, specific objectives in order to reach the highest knowledge level.
- Plan work tasks and their monitoring.
- Develop and plan work team as tool to reach specific objectives.

Finally we brought evaluation process of teams work to a conclusion using a presentation of these four objectives areas.

5. Conclusion

The new methodology developed during the course 2002/2003 has reached much better results than master class methodology.

The sub-group and personalized work, typical of the exposed methodology, has been one of the best choices to adjust a course to students with different interests and backgrounds. By means of this methodology non-technical attitudes and aptitudes required in their future careers has been developed. We want to pay especial attention presentation results they have got.

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