WIND ENERGY EDUCATION FOR ELECTRONIC ENGINEERING STUDENTS

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Abstract

This document presents introductory materials about a doctoral education thesis research project. Education on non-conventional renewable energies, namely education on wind energy, is considered as an emerging paradigm, and is applied by employing Project-Based Learning methodologies as part of the Electronics Engineering program at Universidad Distrital Francisco José de Caldas (Bogotá - Colombia). Since non-conventional renewable energies have drawn great interest in developing countries in recent decades, it is necessary to implement education programs, at all levels, that allow public engagement of these technologies by all the population.

Keywords: Education, Wind power, PrBL, Non-conventional Renewable Energies.

1. Introduction

The renewable energy industry has experienced an unprecedented rise that stems from the growing international concern about global warming and the additional effects of the use of fossil fuels. This has led to a substantial increase in the demand for renewable energy generation systems, also putting pressure on the supply of qualified workforce. There are already indications of a shortage of trained personnel to design, install and maintain renewable energy systems. The renewable energy industry has identified the need for education and training programs at all levels, from community training to technical and higher education tuition. Due to the shortage of experienced instructors and the cost of establishing teaching facilities, it is desirable that governments, the industry and education providers cooperate to identify the needs and share the cost of developing top-quality courses. Such courses should meet the demands arising from the growth in the industry, contributing to the reduction of greenhouse gas emissions. Thus, degree courses and short courses must cover topics such as energy management, energy policy making, and the design of renewable energy systems. Moreover, these courses must be adapted to the professionals already working for the companies that participate in this rapidly expanding industry (Jennings & Lund, 2001, Xie, et al, 2013).

2. Conceptual foundations

2.1 Renewable Energy Education

Renewable Energy Education requires professional, technological and technical programs about renewable energy systems with a strong emphasis on practical applications and the commitment to raise public awareness, acceptance and the widespread use of a variety of energy sources, such as solar, wind, and biomass among others (Andersen, 1986).

Engineering programs, education for the community and technical training in general must be broad in scope. Universities, research institutes and training facilities for technicians must offer a variety of tuition profiles ranging from formal and non-formal programs to high-level policymaking and planning courses, also including a set of activities intended to improve the understanding and acceptance of new technologies by the general public. This type of education should involve the students currently enrolled in schools, colleges and universities (Boris Berkovski and Charles M. Gottschalk, 1997; Gelegenis and Harris, 2014; Cao, Kleit, and Liu, 2016).

Selection and/or peer review under responsibility of Scientific Committee
doi:10.18086/swc.2019.50.08 Available at http://proceedings.ises.org

Recently, Broman, Aadu Ott, and Konrad Blum, published a new document called "A PEDAGOGICAL APPROACH TO SOLAR ENERGY EDUCATION", proposed for Solar Energy Education -SEE- teaching-learning processes that are centered on the student. The approach goes from the teaching of hard sciences to soft sciences and analyzes the interaction between the two. The proposal is based on a design approach that considers neuroscience and didactics for innovation, embracing learning as a social process; all of the above oriented to the REE (Broman et al, 2018). Based on this work and other previous proposals, the Wind Energy Education - WEE approach is put forward and is implemented through a Project-Based Learning – PrBL methodology.

Wind energy education is an imperative need for humanity and, of course, for all Colombian citizens. The Colombian territory has abundant wind and solar energy sources, prompting the need to train the population in the use and adaptation of these technologies. Different training centers should also address research, innovation and development of the technology. In this context, the Electronic Engineering department at Universidad Distrital holds highly skilled, formally trained human resources (professors and students of different levels) that can assume the challenge of developing this technology with an additional perspective that includes a social component by implementing appropriate educational models. Therefore, this paper proposes a definition of Wind Energy Education - WEE-, as follows:

"*It is an emerging paradigm of academic and investigative nature, which seeks to open spaces for the dissemination, promotion, and adaptation of technologies concerning Wind Energy, as well as the acceptance and public commitment by citizens so that appropriate public policies can be articulated for widespread dissemination; this is provided from different perspectives with multidisciplinary solutions to energy and environmental problems*"

2.2 PrBL Methodology

Problem Based Learning (PBL) as a methodology was initially implemented in the 70s for teaching in the medical school at the Canadian University of McMaster, (McMaster page). The methodology provided a solution to the generalized problem of student motivation (Barrows, 1980). Since then, the PBL methodology has gained popularity and is currently considered appropriate to address many of the challenges of higher education (Woods 2000). Its application in the field of engineering and specifically in the area of Electrical Circuits Analysis comes later, but it is already a mature and consolidated methodology (Dart 1996, Barg 2000).

The learning process in the Project Based Learning (PrBL) methodology (Solomon 2003) is based on the development of a project which establishes a specific goal as a final product. The project takes place in an environment with restrictions and constraints. Reaching the established goal will require the learning of concepts, procedures, and attitudes.

The most relevant characteristics (Woods 2000) of the PrBL methodology are as follows:

- The PrBL is developed in a real and theoretical-practical environment. This condition helps the students to relate the theoretical contents with the real world, which leads to an improvement of the learning scope of the theoretical concepts.
- The students assume an active role in the project since they have to set the pace and scope of learning; the objectives of the project are set from the point of view of students.
- The PrBL methodology motivates students; it can be a very good instrument to improve the academic performance of students and promote a better attitude towards their studies.
- The PrBL allows the development of technical or career-specific skills and the development of several general skills such as teamwork, planning, innovation and creativity, initiative, etc.

- The instructor no longer plays the role of a passive observer. The instructor takes the role of a tutor and consultant. The instructor provides sufficient and necessary knowledge at appropriate times to stimulate and support the teaching-learning process.

The relations between instructor, student, and project in the PrBL methodology can be seen in Figure 1.

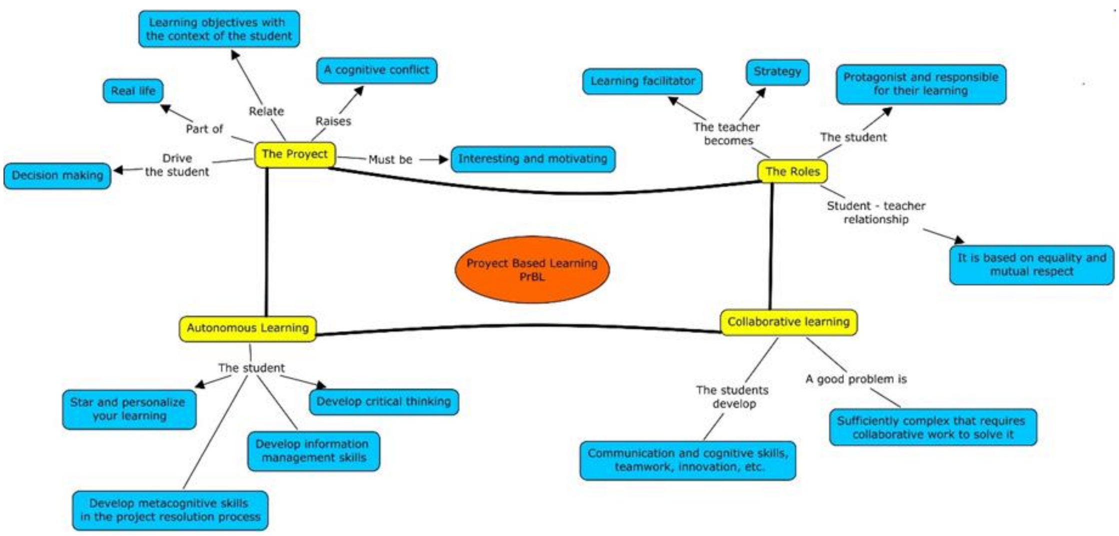

Fig. 1: Relations PrBL.

3. The project

The main goal is to help students of Electronic Engineering become aware of the use of non-conventional renewable energies and particularly the use of wind energy as an alternative to providing solutions to contextualized energy issues. The awareness process is prompted by the development of a project proposed in the subject of Electrical Circuits Analysis. The project also allows students to acquire different concepts and skills in the field of energy. The project proposed in the classroom starts by solving the following problem: Is it possible to design and implement a small wind generator capable of delivering a minimum of 10W of power? To solve the proposed problem, it is suggested that the project approach includes the following stages:

1. Conceptual foundation, 2. An approach to solution strategies and assignment of roles, 3. Documentation of low power wind turbines, 4. Design and implementation of the wind turbine, which includes the following steps: a. Choice of the generator, b. Rectifier stage, c. Choice of the accumulator and, finally, 5. Integration and testing.

The PrBL process started with the participation of second-semester students enrolled in the Circuit Analysis I course and was conducted during the first semester of the 2017 period. Then, in the second semester of the same year, the process was conducted again for students in the same course plus the students of the following course, namely Circuit Analysis II. Initially, the work of students on the project represented 20% of the final grade of the course, then 30% for the two courses involved; currently, the project is worth 50% of the total grade of the courses as it is a process that is still in its construction phase.

3.1 Methodology of project work as a team

At the beginning of the semester, the project is suggested to the students as a work project to be carried out during the academic period and delivered at the end. Rules and objectives are agreed upon. In the second week, students' proposals are heard. Students are then given a document about the design process; this document will be discussed during the fourth week. Students are widely informed about the PrBL methodology with its main characteristics; the methodology is presented as an alternative to the teaching-learning process, which is worth exploring.

Once the students have the opportunity to do some research, together with the instructor, a discussion panel is held in which possible solutions are proposed and doubts are solved. This panel should guide students so that they take a position of critical discussion and contribute to a solution in context. At the end of this stage, students have the opportunity to clearly identify the different modules and the sequence of the process of designing and implementing the system.

The working groups, organized by the students according to their personalities and strengths, work collaboratively and cooperatively. Every member of the group must participate in the process and must organize his/her work for planning and decision making. In addition to assuming roles and leading processes, articulating collaborative work groups contributes to generating indispensable skills in the development of successful projects; communication plays an essential role inside and outside the work group.

A final session is held at the end of the course to conduct a technical test of the project. The test is done in front of the whole class and all students can support each other. This session is intended for students to show their progress, not only in technological terms but in terms of the different types of knowledge acquired, which allows students to speak properly about the concepts of the course, their applications and their relation with the whole electronic engineering program. Students also have the opportunity to show the inconveniences and unexpected issues encountered during the project, which become an important asset to enrich the know-how of future projects.

3.2 Instructor’s role and evaluation

Throughout the semester, the instructor assumes the guidance of students, providing a theoretical framework and technical guidance. Therefore, the instructor must become a driving agent, a motivator for his/her students by creating an environment of trust and collaboration for the different participants in each group. The instructor must be present, observe, listen, guide and help to value the initiatives of the students; the teaching-learning process is now focused on the student.

Joint evaluation of the project must take place. There is a grade (quantitative evaluation) given by students about the work of other groups, a grade given by the group presenting the project (self-evaluation) and the grade of the instructor. Healthy discussion and constructive criticism are encouraged and promoted to support the quantitative result (the grade) of each project. Evaluation is a continuous process; it is a joint construction between the different actors involved in the development of the project. The evaluation becomes a somewhat complex process since there is not enough clarity about what is being evaluated: the knowledge acquired by the student, his performance and the contributions to the project (Mingyang 2004).

4. Conclusions

It has been observed that the development of the project has explicitly promoted skills such as teamwork, planning, innovation and creativity, and communication skills, among others.

The project was successful in encouraging students to develop several skills by integrating technologies and knowledge of certain level of complexity from modules that ultimately integrate into a system, "a wind generator". The process of integrating the system additionally awakens the desire to learn about alternative non-conventional energies and therefore to be educated about energy. As result, a seedbed of GEOM research was created in which the objective is the development of low power wind generators. The findings show that collaborative and cooperative learning was achieved, also indicating that more students keep a high motivational level due to the characteristics of the project.

In terms of teaching objectives, it has been determined that the project achieved a level of learning greater than that of traditional learning based on lectures and laboratory sessions. So far, the experience has been very positive for both instructors and students. The methodology and the didactics have been favorably received by all the students.

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