Learning based on interdisciplinary projects with students from several engineering courses: Case study on energy sustainability

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Abstract

The study of environmental and energy issues are as important as the specific disciplines of engineering courses. Within this context, the Environmental Sciences course provided the students an analysis of the relationship between the specific disciplines of their courses with relevant environmental issues, using the Project-Based Learning Methodology. Students were sorted into teams of ten from different Engineering courses and encouraged to create a project with feasible solutions for economy of energy and use of more sustainable energy sources. As a result, three projects were proposed: *1*. Development of an application where the consumers can analyze their electricity consumption and the best way to save it, using mobile platforms like Android®, IOS® and Windows Phone®. *2*. "Recharge your ideas": project for the installation of an individual photovoltaic system, which is an individual and non-interconnected electrical energy generating system, in order to provide clean and sustainable energy in a safe and satisfactory way at the University campus. *3*. "Low cost solar heater": developed to serve low-income rural communities. A prototype was made to estimate all necessary costs to make it and what would be the return in economy for the residences. With the development of these projects, it is perceived that interdisciplinarity is fundamental to the understanding of the themes developed, requiring the effort of students and teachers from the most diverse areas of engineering. The solution to most of the current problems in different areas of knowledge requires a more effective dialogue between disciplines and between professionals towards more adequate and self-sustainable solutions. To the students in particular, these activities promoted a practical experience and theoretical approach of different processes of Science and Technology and the opportunity to act in the solution of problems based on the knowledge acquired in the course in the resolution of real environmental and energy problems.

Keywords: Project-Based Learning; sustainable development; interdisciplinary.

Type of contribution: Best practice paper.

1. Introduction

Faced with the challenges presented by the world society and the responsibility for training people related to innovation and technological development, it is necessary to reflect on teaching and learning methodologies and the development of more flexible and dynamic curricula for training in different engineering courses.

According to Ministry of Education (2002), that established the new National Curricular Guidelines (NCG) for Engineering Undergraduate Courses in Brazil, engineering education should be in line with the requirements imposed by globalization. According to the Article 3, engineers must be generalist, humanist, critical and reflective, which enables them to absorb and develop new technologies, stimulating their critical and creative roles in identifying and solving problems, considering their political, economic, Environmental and social aspects , with an ethical and humanistic vision, in response to the demands of society.

There are those who defend the idea of an approximation with the productive, technological and entrepreneurial sector and those that defend the approach with the postgraduate and the science. Although these ideas seem to be antagonistic, they must be reconciled in the formation of the professional in a broader and more effective way, so to make this come true there is a need for opportunities to experience different realities in the context of Engineering.

Nowadays, there are several sciences seeking the interdisciplinary approach as a viable way for the organization of their curricula, as they seek the training of professionals who can interact holistically. The health area is one of the highlights, including publications about their experiences (VARGAS et al, 2008). Interdisciplinarity can foster more meaningful learning and flexibility in organizing higher education curricula.

The problems of study in the context of professional practice are linked to action and, from this perspective, a flexible curriculum organization has to be developed, one that allows a professional experience closer to its academic formation and thus becomes more meaningful. According to Vallim et.al., (2000) the emphasis on teaching techniques rather than concepts results in a rapid forgetfulness on the part of students. Teaching theory unrelated to practical aspects does not adequately prepare students for the exercise of their profession.

The theory of meaningful learning was proposed by Ausubel and later propagated and investigated in several areas of knowledge by researchers such as Novak (1977), Moreira (2006) and others. Ausubel proposes that, in order for learning to have a modifying effect on the individual's cognitive structures, it must be meaningful. In making use of this premise, Ausubel suggests the need to define meaningful learning and its opposite, non-meaningful learning.

Another methodology that favors interdisciplinarity and complements it is the Project- Based Learning Methodology. It originated in 1900, when the American philosopher John Dewey (1859-1952) proved "learning by doing", valuing, questioning and contextualizing students' ability to think in a gradual way of acquiring a relative knowledge to solve real situations in projects related to content in the area of studies. Thus, project-based learning, which has been studied in recent years, is associated with constructivist theories, where it is verified that knowledge is not absolute, but is constructed through progressive knowledge and global perception.

The development and success of an Engineering Project is a complex process, since it involves many aspects, like: the students' ability to develop it considering all the variables involved, such as the limitation of time and resources, among others, as well as the skills and abilities acquired; the reorganization of classroom space for facilitation of interaction and shared

knowledge development; integration of new computational technologies; revaluation of the evaluation system, among others. Therefore, its management, due to its complexity, is fundamental to its success. When the curriculum allows for flexibility this can favor greater team performance. The current demands of the labor market require new skills and competences of future engineers (Dobbs et al., 2012). Thus, these new characteristics imply the development of cognitive and relationship skills.

Moraes, 1999, suggests that new guidelines in education and the new profile of the engineer that is being required in recent years require the development of a contextualized subject with multiple intelligences that builds knowledge according to its genetic, cultural and social background. A paradigm that values the learning process, the constant updating of the contents, the adoption of more flexible and adapted curricula to the conditions of the students, that respects the individual and group rhythm in the processes of assimilation and accommodation of knowledge.

2. Objectives

The systemic approach of Problem-Based Learning (PBL) or Project-Based Learning (PBL) involve students in the acquisition of knowledge and skills through a process of investigation of complex issues, authentic tasks and products, carefully planned for efficient and effective learning.

In an interdisciplinary way, promoting the development of critical thinking, teamwork, creativity and capacity to lead processes of innovation of technology and the sustainability of the environment, the aims were:

-Develop a visual product such as prototype, mock-ups, applications, according to the project developed by the team;

- Elaborate a scientific article from the project developed.

3. Theoretical basis and methods

Within the context of engineering courses, the Environmental Sciences course has as main objective the approach of Environmental concepts. It is a daily challenge for teachers who teach such discipline, since many students does not realize how important in their academic background are environmental concepts and applications.

The Active Learning Methodology based on interdisciplinary projects in engineering courses at the Federal University of Itajubá (Unifei, campus Itabira), framed in the PBL (Project Based Learning) model was a facilitator of the teaching-learning process in the Environmental Sciences course.

In order to carry out the projects, the teams were organized in such a way that they were composed of students from the following engineering courses: Computing, Mobility, Health and Safety, Production, Control and Automation, Electrical, Mechanical, Materials Engineering.

In this way, the projects should have contributions and perspectives of different visions, because the students have different academic formations, that is, with emphasis in a certain area of the different Engineering Undergraduate Courses. The projects should respect the pillars such as:

- Be based on projects with real results;
- To work in teams, respecting other opinions (even if contrary to yours), inducing them to take an active and responsible part for their learning;
- Develop carefully planned products for efficient and effective learning.
- Develop critical thinking, with teamwork, presenting creativity and the ability to drive innovation processes of technology and the sustainability of the environment in their products.

The selection of the project to be developed in the disciplines is fundamental in the application and success of the PBL, since it must be able to motivate and lead the learner to new discoveries, minimally covering the programmed content defined for the course. A project is a temporary effort undertaken to create a unique product, service or result and this temporary nature indicates a well-defined beginning and end, taking care of proper management in its development, applying knowledge, skills, tools and techniques (Campos, 2011).

The work was organized in stages over 16 weeks. In 9 weeks a specific activity of the PBL was developed and occurred the delivery of products, in the other weeks contents of the course were studied with the objective of integrating the students with subjects pertinent to the learning proposed by the discipline. As a product of the proposed project, students presented their proposals orally, implemented and planned new project ideas, developed prototypes, and wrote articles as final outcomes, as outlined in Figure 1. The evaluation of the learning process occurred in each of the stages, each product delivered to the team was evaluated if the proposed objectives were achieved.

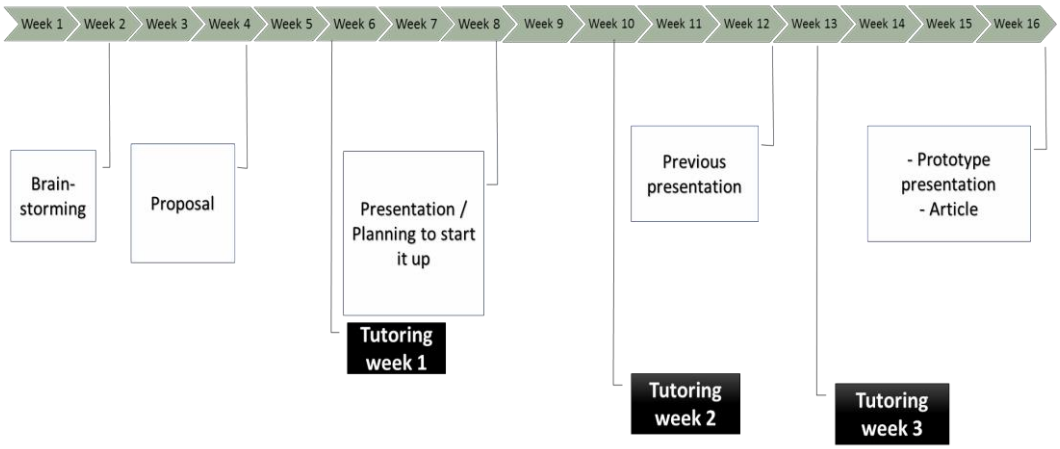

Figure 1 – Schedule of the process during the 16 weeks of the course.

The contributions of the active methodologies are diverse and allow us to predict that, instead of students leaving school with the illusion of having learned something just because they were participating in the lesson and had access to the contents in lectures, we will have students experiencing learning situations deeply significant in their lives (Blikstein, 2012).

4. Results and Discussion

As a result, this work created interdisciplinary conditions, where the solution of the problems exceeded the boundaries related to the discipline, generating works applied in the different areas of Engineering such as Mechanics, Computing, Automation and Production without losing focus in the environmental aspects.

During the evaluation process, it was noticed that the ability to solve problems and create more sustainable solutions motivated the students in the development of all the stages of the project, favoring the acquisition of new complex and changeable knowledge, parallel to the development of professional attributes that pass necessarily by the differentiated and alternative methods to facilitate this broader formation.

4.1. Projects developed

One of the teams has developed an application where consumers can analyze their electricity consumption and how best to save money using mobile platforms such as Android®, IOS® and Windows Phone®, in a project entitled "Save energy: a new way of electricity management in residences". The group concluded that new technologies are constantly associated with the high consumption of electricity, causing, therefore, enormous damages to the nature. Furthermore, this study showed that several innovations could be combined with sustainable projects, so it is necessary to have a vision focused on the environment.

This project proved to be feasible, requiring some adjustments in order to improve the proposed objectives. One of them is analyze in the residences the electricity consumption estimated according to each electric and/or electronic device. In this situation, the application will give tips to users and make suggestions to save energy.

According to the group, "studies of sustainable projects and the impacts of new technologies on the environment are very important to engineering students as they add knowledge about the preservation of nature and will be of great value when future engineers work in the job market". It could be perceived that the applied methodology can favor the perception and the capacity of integration of all the teams, encouraging personal and group habilities.

As a result from the learning in this work another group worked on the "Recharge Your Ideas" project, where they developed a prototype to use an alternative source of sustainable energy at the University. With photovoltaic panels that convert solar radiation and transform it into electricity, being able to charge the electronics of campus community, such as cell phones, tablets and notebooks among others. In order to reach the results, it was necessary the support of several disciplines of the Electrical Engineering course, that were capital to achieve the desired outcomes. With regard to the operation of the system, it became a goal of the team to develop a voltage controller for the solar panel to obtain continuous energy to power the battery of smartphones and notebooks. The electronic circuit of the voltage controller was developed according to Figure 2.

The researches of the team occurred outside the class, which allowed greater team interaction. Group meetings initially had the purpose of acquiring the necessary knowledge for project and prototype development. Taking into account also the concern with the sustainability of the project, the researches were also focused on obtaining knowledge about clean and renewable energy, which allowed the team to interact more about environmental issues and their responsibilities as future engineers.

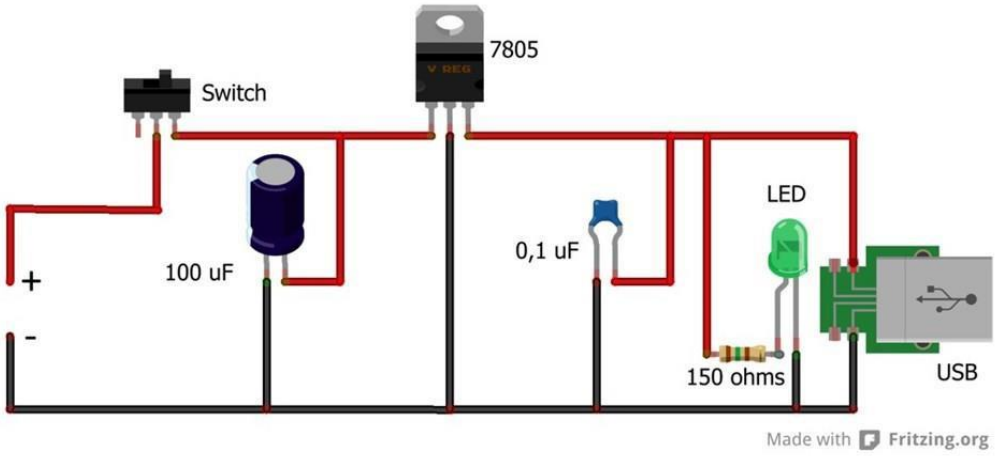

Figure 2 - Electronic circuit for the voltage controller of the solar panel. (From: www.tecmundo.com.br/area-42/60526-area-42-fazer-carregador-solar-celular-video.htm).

During the course of this work, the students were able to socialize knowledge of diverse areas allowing a wide, applied and interdisciplinary knowledge thus achieving one of the objectives of the proposal, as outlined in Figure 3.

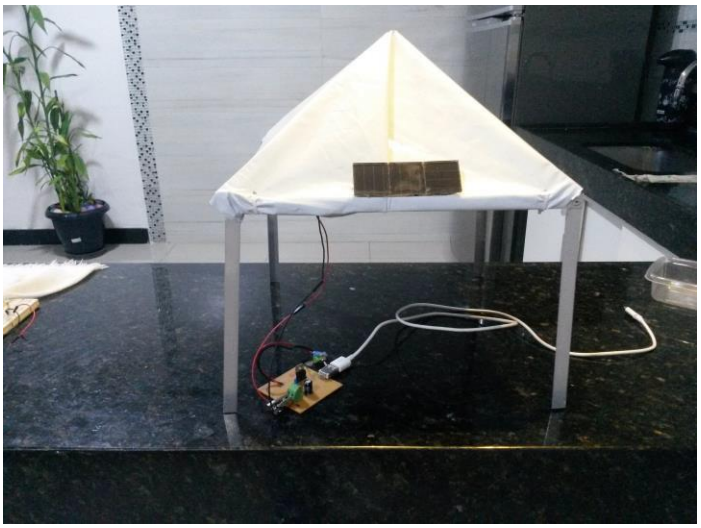

Figure 3 – Team's prototype of the solar energy system.

The group concluded that research on this type of use of solar energy is fundamental to provide infrastructure as points of electronic loading widely used daily for the entire academic community in university campus as a source of clean and renewable energy. Thus, it will be possible, besides offering convenience, an intense awareness of respect and preservation of the nature of those who use this type of energy to charge their electronic devices.

A third group developed a prototype of solar heater to serve low-income communities. According to the group the project was able to provide the evolution of the skills of teamwork, as well as the development of critical thinking regarding sustainability and the commitment of those involved with social responsibility.

5. Conclusions and Recommendations

It is perceived that what was pleaded for more than a decade is still a real demand and of great impact in the teaching process learning of all areas of knowledge. It is only from new educational perspectives that stimulate the capacity to learn in a broad way, the development of thought and consciousness, that we will be collaborating in the development of new generations of more ethical, creative, autonomous, cooperative, being able to lead with uncertainty, to the complexity in the decision making and to be more responsible for the decisions taken in different situations in the academic and professional tasks.

The learning by projects together with an interdisciplinary approach favors the relationship among contents, facilitating to the students the construction of their knowledge with the integration of the different disciplinary knowledges, looking for a meaningful learning. That is, take as a starting point students' previous knowledge for building / expanding knowledge and make them aware of their learning process, as they learn to learn, developing their capacities of choice, decision, planning, take on responsibilities and being agents of their learning.

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