Using a Home Energy Audit to Promote Active and Cooperative Learning

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Abstract: - This paper describes the use of a Home Energy Audit as a mandatory assignment within the subject of Energy and the Environment taken by final year Mechanical Engineering students. The process is designed to promote active and cooperative learning and provides an opportunity for student critical thinking and effective learning. This process allows students to be exposed to a wide diversity of practices and promotes contact with real world applications, while contributing to student learning motivation and encouraging a creative approach.

Key-words: energy audit, environment, active learning, Problem Based Learning

1 Introduction

Establishing and maintaining a learning environment that is conducive to effective learning is a priority for science teachers, who often wonder how to improve lectures and increase students´ interactivity so as to achieve a better engagement in the learning process. This can be accomplished either by producing better materials and contents, making use of Information and Communication Technology (ICT) and/or by promoting adequate and more flexible learning environments which will be conducive to effective learning. The benefits of student-centered teaching, web-based teaching methods, team work and collaborative learning environments have been the subject of several demonstrations and studies [1-11].

The use of the present approach to engage undergraduate students in the learning process has proven to be of value particularly when some factors and needs are present [8, 9]:

- access to updated information and online simulators
- increase student's motivation
- schedule flexibility
- stimulate and support different learning styles
- accomplish more with less in a crowded curriculum
- incorporate modern teaching tools / approaches
- promote contact with real world applications / cases
- work and develop non-technical skills

The main objectives of the present study can be summarized as follows: to provide a wider choice of styles and opportunity for student learning; to understand how students get engaged with the Problem Based Learning approach; to assist students in "learning how to learn", which is one of the major needs for effective learning in the Engineering Sciences; to promote interaction and collaboration by sharing information and; to increase the students' engagement and responsibility in the learning process. A detailed description of the systematic approach to course design and successive versions of implementation along with the description of the overall proposed learning/teaching activities and online collaborative environment for the Energy and Environment subject are discussed elsewhere [12, 13].

The present case is carried out with 5th year students of the Mechanical Engineering degree course within the Energy and Environment subject. The following section describes the methodology used giving emphasis to the overall learning environment. Some discussion and considerations are outlined concerning the learning styles, the learning environment characteristics and analysis of the learning activities and methodologies. The last

section summarizes the main conclusions and underlines the need for future work.

2 Methodology

2.1 Background

In the Energy and Environment course the main part of the lectures is spent covering parts of the syllabus which are more difficult to access and/or are more critically relevant. The lectures revolve around visual information in the form of diagrams, charts, pictures, plots and animations. They are a blend of traditional lecturing combined with demonstrations, applications and discussions giving a higher emphasis on deductive thinking, comparison and understanding. The compilation of course materials is not exclusively on the side of the lecturer but is shared with the students, as they are held responsible for gathering course material that supports subjects either discussed or not in class but which are related to the course curriculum. The students are requested to cover by themselves a wide part of the syllabus while being coached through the process. This student-centered approach is seen to promote creative thinking, structuring skills and contacts with open questions which can not be promptly answered in the traditional text books [2].

In the Energy and Environment course, where a large syllabus needs to be covered, students are required to participate in two distinct learning events: i) a thematic work with an online component covering cooperative and collaborative learning and peer review [12, 13], and; ii) an Energy Audit in their own homes.

2.2 Energy Audit

As an assignment students are requested to perform an Energy Audit in their own homes. The main objective to identify whatever helps or prevents energy conservation in each own home. By the end of the semester the students have to present their own case study and propose actions for improvement (Efficient Energy Utilization).

Stating the Problem:

- Audit the energy consumption to determine which types of energy are used and the amount of each.
- Analyze which equipment/appliances/processes consume extensive amounts of energy
- Plan measures by which you can conserve energy used in high-energy consuming processes.
- Provide a list of actions that were or should be implemented as an attempt to reduce the consumption of energy in your home.
- Identify the major construction, maintenance and design features that make buildings energy efficient.

Following an introduction to Energy Management the students are given some tools:

- web-based high quality and rich contents related with energy efficiency [14-16];
- several online simulators [14, 15, 17], as the examples provided in Fig.1;
- an Excel file and a detailed explanation on procedures, measurements and goals;
- a collaborative working environment [13].

The Excel file consists of several spread sheets (a basic Energy Audit checklist) namely Identification, Characterization of the building undergoing the audit (e.g., consuming equipment / appliances and related characteristics, heating / cooling, lighting, etc.) and the related Tables for measurements (electricity, gas and water). The acquired data can be automatically visualized in the last sheet of the file. This way all the students will have the final data in the same format, which makes it easier for comparison purposes, and some corrective actions can already be implemented during the audit timeframe and monitoring and results' analysis can be performed within the approach presented in Fig. 2.

On completion of this activity, the students should be able to:

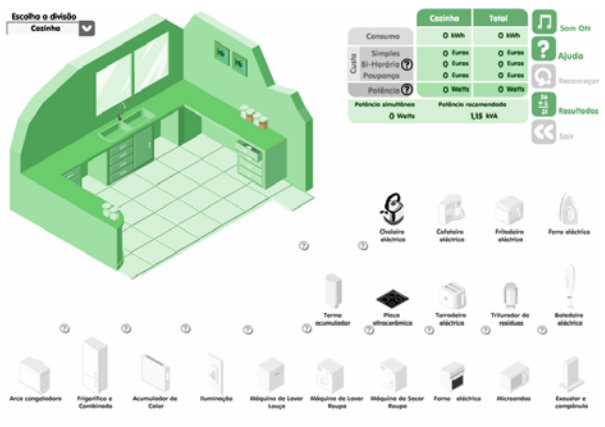
- identify the major construction, maintenance and design features that make a building energy efficient;
- comfortably use energy management terms;
- reduce waste of energy and money;
- explain energy saving steps.

3 Sample Results and Analysis

The students are requested to analyze their own electricity, gas and water consumptions, to identify possible ways of Efficient Energy Utilization and implementing, if possible, adequate measures and monitoring the results. Sample results of the energy audit are shown in Fig. 3 for electricity, gas and water consumption. The plots are taken from the last spread sheet of the .xls file.

The students must deliver their Energy Audit .xls file and give an in-class oral presentation (Power Point) stating their case, main findings, implemented actions, monitoring, etc. They usually also provide a long list of actions for saving energy and water at home [18].

a)



b)

Fig. 1 – Electricity and water simulators (Kitchen)
a) Electricity [14]; b) Water [15]

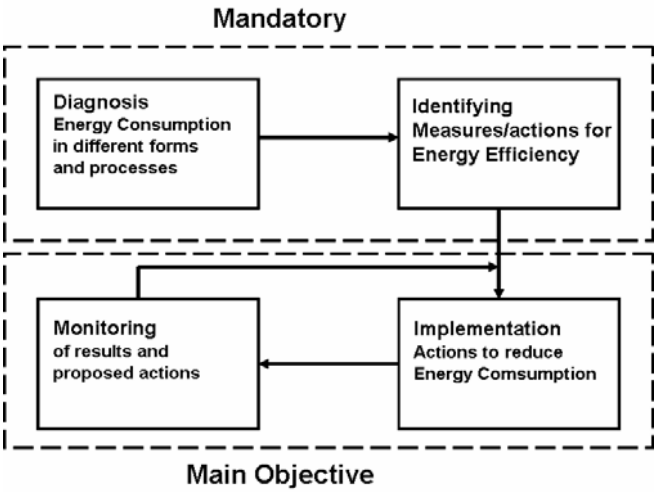


Fig. 2 – Schematic Diagram of the Energy Audit tasks and actions

Some of the students do not achieve the main goal of the proposed assignment, i.e., they do not bother or care to "jump" from the Mandatory to the main Objective part of the work as shown in Fig. 2. However, there are students who perform surprisingly well. In these cases is it usually evident that the entire household (family) got deeply involved in the process and real improvements, during the audit timeframe, are seen towards achieving a more energy efficient household.

As students are confronted with a less traditional way of learning (as opposed to the traditional "knowledge acquisition"), there is some initial ambivalent reaction to an assignment which has to be maintained along the whole semester. This fact plus all the other activities proposed within the Energy and Environment subject, described elsewhere [13], are taken into account in the planning of the first lectures of the semester. This initial contact needs to be very objective and straightforward and the whole layout of the course is presented along with the related assessment tools.

Once they get started and acquainted with the reference material, the already prepared .xls file and the online simulators, most of them will willingly follow the paths to "active learning", "problem based learning" and "learning by doing". These classes are lively and each ones case or specific question is discussed on a weekly basis and the students are encouraged to provide each other answers and alternative solutions.

These tools and methodology seek to give students more responsibility as well as to increase their engagement in the learning process. They allow students a wider choice and diversity of practices and promote contact with real world/applications, while contributing to student motivation and encouraging a creative approach to the issue. Students usually end the semester with the satisfaction of self-achievement and of having become more autonomous learners.

There are, however, some factors which need to be present for a successful result: clear rules; good balance between old and new methodologies, and getting learners to focus. These "simple" tasks are, however, not easy to achieve.

The students who get highly involved in this process tend to be more confident along the semester and some will perform surprisingly well by the end of the course. However, there are drawbacks as some students: i) never get committed enough; ii) do not adapt to the new methodology, and; iii) tend to prefer the traditional lecturing, which requests less effort from them on a weekly basis.

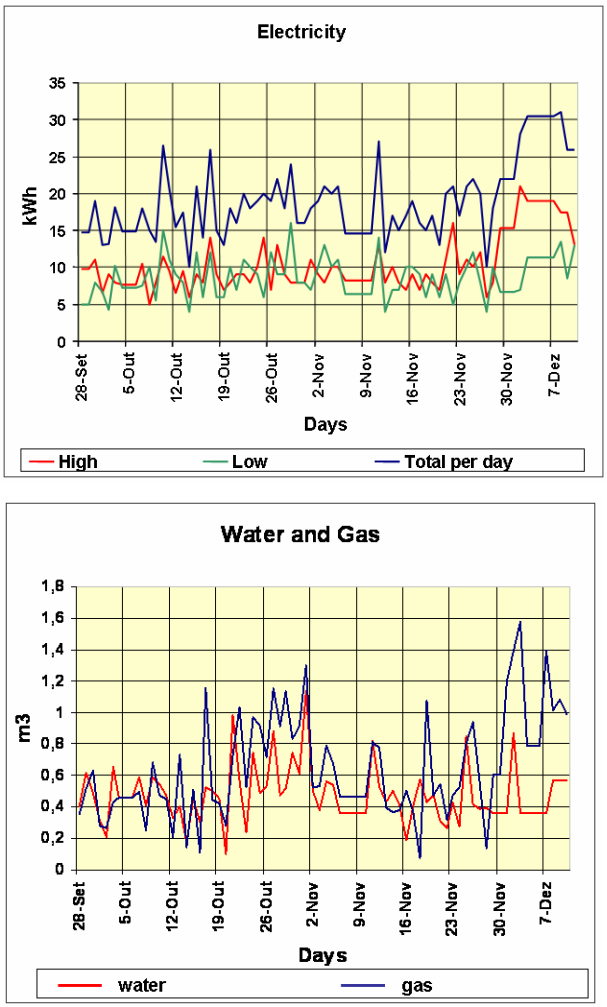


Fig. 3 – Electricity, gas and water consumptions
a) Electricity; b) Water and gas
(Author's values, Sept.– Dec. 2003)

One of the most positive outcomes of this work arises from the multiplier effect. Often, not only the whole family gets involved but also friends, neighbour and others willingly join the process. On occasion, one or two years later, students come back and report on how they continued this Energy Audit work or how important it is for their present job. Some of them even started to implement simple and preliminary Energy Audits at their work place.

This is in line with the need for acquiring and developing non technical competencies on an Engineering course, as opposed to the standard stand alone approach [19].

4 Conclusions

The reported work describes the design and implementation of a Home Energy Audit, which is intended to establish and maintain a learning/teaching environment conducive to active and cooperative learning. Students discover new concepts and ways on their own and become more motivated, more creative and more interactive.

In teaching "how to learn" and through the understanding of different learning styles, attitudes, motivations and evaluation result analysis there is also room to "learn how to teach". Hence, present and future work addresses the following issues:

- Up-front demand related to collecting up-to-date information from the Energy bills for electricity, gas and water for the present and past year (until now this was not a prerequisite);
- The establishment of check-points to secure the achievement of the main objectives of the Energy Audit (Fig.2);
- Secure the implementation, with minimal cost implication, of energy saving opportunities identified during the energy audit time period;
- Providing more guidance to enable students to deliver a well structured Energy Audit Report at the end of the semester.

References:

[1] Felder, R.M., Silverman, L.K., Learning and Teaching Styles in Engineering Education. *Engr. Education*, Vol.78, No.7, 1988, pp.674-681. preceded by the Author's Preface of June 2002: http://www.ncsu.edu/felder-public/Papers/LS-1988.pdf retrieved 29/1/2007.

[2] Felder, R.M., and Brent, R., 1996, Navigating the Bumpy Road to Student-Centered Instruction, *College Teaching*, Vol.44, pp.43-47, http://www.ncsu.edu/felder-public/Papers/Resist.html

[3] Krezel, Z.A., Pocknee, C., Moving Towards Project-Based Learning: A Case Study Looking at a First Year Civil Engineering Subject, *Fourth International Workshop on Active Learning in Engineering Education (ALE)*, 6 – 9 June, 2004, Nantes, France.

[4] Braga, W., Evaluating Students on Internet Enhanced Engineering Courses, *32nd ASEE/IEEE Frontiers in Education Conference*, 6-9 November, 2002, Boston, MA, USA.

[5] Braga, W. Teaching Strategies for Undergraduate Heat Transfer Courses, *Proc.*

ASEE Annual Conference & Exposition, American Society for Engineering Education, 2002, Session 1566, Montréal, Quebec, Canada.

[6] Salmon, G., *E-tivities: The Key to Active Online Learning*, Kogan Page, U.K, 2002.

[7] Rhee, J., Teaching Efficacy of Web-Based Teaching Methods in an Undergraduate Thermodynamics Course, *World Transactions on Engineering and Technology Education*, Vol.2, No.1, 2003.

[8] Oakley, B., Brent, R., Felder, R.M., and Elhajj, I., Turning Student Groups into Effective Teams, *J. Student Centered Learning*, Vol.2, No.1, 2004, pp.9-34.

[9] Smith, K.A., Sheppard, S.D., Johnson, D.W., and Johnson, R.T., Pedagogies of Engagement: Classroom-Based Practices, *J. Engng. Education*, January, 2005, pp.87-101.

[10] Felder R.M., Elhajj I., Brent, R, Oakley, B., Turning student groups into effective teams, *Journal of Student Centred Learning*, Vol. 2, No. 1, 2004/9.

[11] Pincas, A., Gradual and Simple Changes to Incorporate ICT into the Classroom, 2003, www.elearningeuropa.info/index.php?page=doc&doc_id=4519&doclng=6&menuzone=1 (Last accessed March 2007).

[12] Carvalho, I.S. and Williams, B., A Systematic Approach to Course Design at Subject Level on a Mechanical Engineering Course so as to Encourage Active Learning. *WSEAS Transactions on Advances in Engineering Education*, Issue 6, Vol. 3, June 2006, pp.482-487.

[13] Carvalho, I.S., Promoting Active Learning in Mechanical Engineering. *ASME International Mechanical Engineering Congress and Exposition*, November 5-10, 2006, Chicago, Illinois, USA, IMECE2006-15664.

[14] EDP, Electricity of Portugal, www.edp.pt

[15] EPAL, Water Company, www.epal.pt

[16] GalpEnergia, www.galpenergia.pt

[17] Several Simulators: House Heating, Electricity Contracts and Low Cost Consumption Hours, www.deco.proteste.pt

[18] Energy Savers: Tips on Saving Energy & Money at Home, *U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy*, January 2006.

[19] Ravesteijn, W., de Graff, E., and Kroesen, O., Competent to Communicate Technology: A New Perspective on Developing Communicative Skills in Engineering Education, *Proc. 33rd SEFI Annual Conference - Engineering Education at the Cross-Roads of Civilizations*, September 7-10, 2005, Ankara, Turkey, pp.480-486.