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Including Cooperative Online Learning at Subject Level on a Mechanical Engineering Course

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Abstract: - This paper describes the use of cooperative online assignments in tandem with traditional lecture methods in the subject of Energy and the Environment on the final year of a Mechanical Engineering program so as to encourage active student learning.

Key-words: - Cooperative, active learning, online, energy, environment

1 Introduction

Since the appearance in 1988 of Felder's paper on Learning and Teaching Styles in Engineering Education [1] which concluded that there was a mismatch between most engineering education and the learning styles of most engineering students, there has been an increasing interest in developing teaching techniques to address all learning styles with a particular emphasis on the importance of active learning supported by pedagogies of engagement, usually involving a cooperative or problem-based approach.

Examples can be found at subject level such as Krezel and Pocknee's work [2] with project-based learning on a first year Civil Engineering course and Braga's [3] use of computer-enhanced learning to study Heat-Transfer on a Mechanical Engineering course. Vos [4] describes the implementation of active learning organisation at departmental level in the area of Electrical Engineering. Other higher educational institutions have implemented an active learning approach at a broader curriculum level: INSA-Lyon [5] offers a two-year curriculum in Technology Science and Innovation using active learning while the Amsterdam University of Professional Education provides a competency-based program leading to a primary degree in Engineering Design and Education in the belief this approach leads to active-learning and will produce technical engineers better equipped to meet the needs of industrial enterprises [6].

In parallel with these developments in engineering education, the emergence of the Bologna Process in European Higher Education has led to a growing interest in developing new ways of promoting learning from a competence-based perspective in all areas of higher education. The Tuning Methodology [7] has been developed at European level to establish reference points for common curricula on the basis of agreed competences and learning outcomes. This approach considered two broad types of competence: generic and subject-specific and attempted to identify such competences across the higher education curriculum. From 2000 to 2004, nine subject areas were studied, including Chemistry, Physics, Earth Sciences and Maths and subject specific competences were presented for each. Although no engineering courses have been studied yet from a Tuning Perspective, one possible basis for such an approach can be found in work already mentioned at the Amsterdam University of Professional Education where Schat-Zeckendorf and Nieweg [6] describe competences (or competencies – the terms are often used interchangeably) as clusters of three essential components: skills, attitudes and knowledge elements. In the design of their Engineering Design and Education curriculum, they formulate the desired outcomes in terms of professional competencies which go to make up the competency profile of their graduates which they set out in the form of a matrix.

As the implementation of the Bologna Process in European Higher Education over the next four years will require higher education courses to accommodate competence-based and learner-centred curricula, for those involved in engineering education within this area this would seem to present an excellent opportunity to ally the competence-based active learning approaches being developed in engineering education with the philosophy of Bologna and the Tuning Methodology.

With regard to classroom practice and active learning, various authors have described studies which show the effectiveness of cooperative learning engineering education as an important element of course design in encouraging engagement of undergraduate students and contributing to active learning [8, 9].

Cooperative learning has been defined as the instructional use of small groups so that students work together to maximize their own and each others' learning [10]. As Smith et al [8] commented in 2005 after a comprehensive review of the benefits of cooperative learning found in the Engineering Education literature: "Of the three key aspects of cooperative learning and problem based learning — theory, research, and practice — the practice piece is the least developed and probably the most difficult. The classroom practices involved with cooperative learning and problem-based learning are complex to both design and implement, as well as to manage during the term".

Smith proposes that effective implementation of formal cooperative learning groups in a well-structured learning environment requires the following elements:

- Positive interdependence
- Face-to-face promotive interaction
- Individual accountability/personal responsibility
- Teamwork skills
- Group processing

To incorporate these five elements at subject level within a traditional lecture centred institution, a course design was chosen which would incorporate individual project work and report writing, pairwork with inter-pair cooperation and individual student presentation functioning in parallel with a reduced number of formal lectures.

2 Background

The students described here take Energy and the Environment as a compulsory subject over one semester in the fifth year of their degree course leading to a Portuguese Licenciatura (B Eng equivalent) in Mechanical Engineering. To encourage more autonomous learning and knowledge construction, it was decided that, in addition to the formal lectures, students would be set two additional tasks: one individual and the other Cooperative with an online component.

3 Methodology

3.1 Tasks

As this would be the first experience of online work for most students, it was decided to use tightly structured learning tasks and simple technology (email).

Students were expected to participate in two distinct learning tasks:

- Cooperative online posting of information on a topic leading to a presentation during lecture time and a written report. Here students work in pairs, and these are expected to post about their own work and comment the post of another pair each week.
- An Energy Audit of their own homes carried out individually.

3.2 Cooperative online posting

Both day students and evening-class students are typically in groups of 20 to 25. As there are 10/12 distinct themes, students divide themselves into pairs and are expected to do background reading on a different aspect of their theme each week, post an informative and structured message on this and also comment on the work of a specified other pair of colleagues/group.

The specific energy related themes covered were:

Buildings, Geothermal, Nuclear, Hydrogen, Cogeneration, Wind, Biomass, Transport, Photovoltaic Energy. The focus over the six weeks moved through the following stages: Theme Introduction, Technologies, Applications, National issues, International issues, the Future and References and each week the pairs were expected to post about the prescribed aspect of their theme and comment on a specified aspect of another pair's work. The weekly posts were be based upon online or library research.

On completion of the six weeks, each student pair was expected to have posted about each of the above six aspects of their theme and to have commented on an aspect of each of the other pairs.

At the end of this period, student pairs began their presentations during class time, assessed individually by the subject lecturer and at the end of the semester they submitted a report on this theme which was also assessed.

The tool used for the online collaboration was a single web-based mailbox to which all were given the username and password. Students were given detailed guidelines on how their subject header should indicate their topic and whether they were initiating discussion or responding.

The pairs were assigned one of the course themes on a first-come-first-served basis at the beginning of the semester and over the following 6 weeks they posted their findings and reflections online for comments by their peers / tutor.

At the end of the course each group has to present the theme in a seminar-like format and the final timetabled lecture slots of the semester are mainly dedicated to student presentations. The students present their work in class to their peers. At the end of the presentation the lecturer acts as a moderator for the discussion and provides feedback.

3.3 Energy Audit
Following an introduction to the subject and given different practical examples the students were given an Excel file and a detailed explanation on procedures, measurements and goals. The file consists of several spread sheets which included Identification, Characterization of the case undergoing the audit (e.g., equipment and related characteristics, areas, etc.) and tables for measurements (electricity, gas and water). The acquired data can be automatically visualized in the last sheet of the file. Some sample results on this task are provided in Carvalho [11, 12].

At the end of the semester the students are expected to present their own study case and propose actions for Efficient Energy Utilization.

3.4 Assessment
The weighting of the final mark awarded to students was: Energy Audit: 30 %, Oral Presentation 40 %, Written Report 30 %.

Students were told that three aspects of their work would be considered in assessment:

- Content
- Structure and Organization
- Ability to get their message across to the target audience

3.5 Role of the tutor
This approach involves the subject lecturer taking on a number of responsibilities in addition to lecturing core material and carrying out assessment:

- task organization and allocation
- monitoring participation during the online cooperation phase and contacting students who had not participated
- organizing the project presentation sessions
- organizing in-class seminars and field trips
- providing ongoing guidance regarding relevant bibliography

4 Commentary
All students participated in the online component although not all of them, as in a face to face classroom, were equally active participants. Regular stimulation and encouragement needed to be present in the online environment.

The students, although initially hesitant in many cases, tended to get more involved over the 6 weeks of the online component and become more motivated, more creative and more interactive in the face-to-face sessions.

End of semester feedback questionnaires from students were predominantly favourable on the methodology adopted although some commented on the work-load and time commitment involved.

5 Analysis and Suggestions for future development

5.1 Technology
In this first implementation of cooperative online work on the course, the mailbox was selected as the tool for online learner knowledge sharing because of its technological simplicity and portability: a

mailbox can be created and maintained without any dependence on institutional servers or IT support and it can also be easily adopted by non IT–minded colleagues. It also gives a clear structure to student tasks: to log on at least twice weekly to post your own findings and comment on the findings of a specified pair of colleagues.

However this tool does not encourage ongoing discussion about the issues raised. Online interaction and debate could be encouraged by replacing the mailbox with either a mailing list (for simplicity and institutional independence) or by opting for a greater degree of sophistication (and concomitant need for IT support) and choosing a portal or learning management system. After considering these options, it was decide to adopt a discussion forum for online cooperation on the next version of the course.

5.2 Methodology

Although the use of self-selected student pairs on the course has the benefit of organizational simplicity, its value in encouraging the development of the kind of teamwork competences which are important for the professional engineer is limited. On future iterations of the course, learners will work in 3-4 person instructor-formed groups and the guidelines proposed by Felder et al [13] (for example team policy, group roles and peer ratings) will be followed to turn these groups into effective teams.

6 Conclusion

It is possible to achieve valuable learning experiences and competence acquisition using structured cooperative online tasks and simple email technology but it would be useful to look at a more enabling technology and introduce different approaches to learner grouping and peer evaluation in future versions of the course.

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