Development of A Learner-Focused Engineering Subject

Jafar Madadnia[1], Homa Koosha[2]
Faculty of Engineering, University of Technology, Sydney (UTS),
PO Box 123, NSW 2007, Australia
[1] Jafar Madadnia, Senior Lecturer,
Email: J.Madadnia@uts.edu.au, URL:http://www.eng.uts.edu.au/~jafarm.
Tel. + 61-2-95142740, Fax +61-2-95142655
[2] Dr Homa Koosha, Email: hkoosha@iitd.uts.edu.au

Abstract: This paper examines the development of a multidisciplinary energy-engineering subject titled "***Energy Conversion***." By which we show that it is perfectly possible to develop an engineering subject aimed at promoting sustainability criteria, using student-focused teaching-and-learning to facilitate deep learning and skill development. The subject content, teaching methods, and student assessment techniques have been aligned to develop the graduate attributes expected of reflective practitioners. Combined face to face, web-site and TopClass facilities have also been developed to provide an interactive learning environment. Students demonstrate the quality of their understanding of the multidisciplinary nature of this subject through making links between theories of the subject and practice in the real world. This requires them to develop skills in critical reflection, analysis, synthesis, integration, creation, and the application of ideas. Students are encouraged to be more pro-active and to consider economic, environmental, political and social factors, in their technical decisions. The paper discusses ways in which we have examined the effectiveness of this approach by interviewing students, and analyzing their reflective portfolios, case study reports, and feedback surveys. It therefore draws out the wider implications for extending student-focused-teaching and learning to all engineering subjects

Keywords: Engineering Education, Student-focused-teaching and learning, Sustainability, Energy Conversion.

Introduction

The challenge of leading the rapidly changing integrated global community, with its ever-increasing expectations of Universities as accountable service providers, requires graduates to be sensitive to community needs and have a proactive attitude towards developing life-long learning skills, reflective practice, and leadership in society. Universities are facing the important challenge of training graduates who are agile-proactive-leaders, reflective practitioners, sensitive to community needs, and promoters of sustainability values. The necessity to develop a sustainable new millennium, associated with rapid global changes in social values and expectations, prompted rethinking in all disciplines, especially in education as an instrument for change.

Agenda 21 of the United Nations at the Earth Summit in Rio (1992) addressed the importance of engineers and decision-makers to achieve sustainability. The engineering education culture in Australian Universities is significantly enhanced by adoption of the recommendations of the National Review of Engineering Education [1]. At the Faculty of Engineering, University of Technology, Sydney (UTS), those recommendations have been applied by restructuring, and re-evaluation of values and missions. Sustainable development and life cycle analysis were incorporated as key elements in the broader undergraduate engineering courses by including environmental, social and economic impact analysis of technical decisions. Parr et al. (1997) outlined how the UTS Faculty of Engineering was successfully restructured both to address the cultural changes and promote practice-based, learner-focused teaching-and-learning curriculum, with sustainability principles as a value system [2].

Generic skills such as critical thinking, interpersonal communication skills, and reflective practice are also incorporated in the course design to enable engineering graduates to become reflective practitioners with capability to analyze, synthesise, create, and apply knowledge.

Understanding sustainability as a graduate attribute

Student-focused teaching-and-learning

The combination of sustainability as a desired value system, and student-focused teaching-and-learning, require action for change at all levels, especially by academics staff in the development of new subjects. All these recommendations, reviews, and expectations place enormous pressure and responsibilities on engineering educators to produce appropriate learning skills and value systems.

The development of Energy Conversion responded to the above by a combination of factors: global (Agenda 21), national-professional (IEAust policy on sustainability), institutional (UTS Sustainability Policy [3]) and moral, which together set the educational standards for the subject.

Reflective approach for developing the subject and improving teaching

We believe teaching involves helping students to develop structured-based knowledge by motivating them to participate in activities, which enhance learning. Therefore a suitable informal collaborative and friendly learning environment is needed to encourage students in team activities leading to changes in their understanding [4]. This is in keeping with the theoretical approach of Ramsden [5], that sees teaching and learning as two sides of a coin, and that teaching methods, student learning, and subject materials are linked to address objective learning. Our understanding of teaching is also expressed in a way similar to that by Bruner [6], which highlights the fact that the key to improved learning lies in students' conceptions, perceptions and ownership of the process. We need to change student conceptions, as stated by Marton and Ramsden, [7], which requires continuous efforts, in collaboration and partnership with students. That leads us to believe good teaching involves monitoring, assessing and improving the effectiveness of the curriculum, teaching methods, and assessment techniques. The important role of case-study based learning results from the students' control of their learning, identification of the problem, planning the process of investigation, evaluation of alternative solutions, regular progress reports through the whole semester, and finally concluding the project on time.

Applying this approach in the Energy Conversion subject

Energy Conversion covers many disciplines, which are constantly changing because social and political decisions and governmental regulations affect this subject and these make it controversial and hence difficult to learn. Our main goal was to help students to understand the basic design of energy conversion systems, in the context of relevant environmental, economic, and social, as well as technological, factors. This undoubtedly generates some controversy as each factor is quantified and valued differently by different people. For example, one can find excellent advantage in nuclear power generation in the context of global warming, but at the same times non-technological factors such as social acceptance can argue against the development and application of this energy system.

The objective of the subject also was to co-create a common understanding of the quality standards in the selection and promoting of a sustainable energy system. Therefore, students are encouraged to learn the fundamentals of a sustainable energy conversion system, and to develop reflective skills to recognize conditions in which a system is sustainable when the above factors are taken into account. To make this possible, in three hours of face-to-face classes, students are exposed to the important aspects of the subject derived from a large body of multidisciplinary technical information, interspersed with buzz-group discussions and active reflection on their own learning and student-focused learning strategies through group discussions. Lectures provided some reference information on the impacts of energy related decisions and actions on society and environments, as well as some appreciation of the important role of non-technological factors and interest groups in shaping the development of energy technologies.

Students selected original, innovative, and individual case study projects, which demonstrated the quality of their learning, skill development, and contributions in their scholarly team activities including discovery, co-creation, analysis, synthesis, integration and application of knowledge, considering technological, environmental, economic, political, and social factors in their decisions. The case studies were developed progressively over the semester, during which an individual weekly progress report was prepared, and presented orally and in writing by students to their team members, and the feed back used to further improve their presentation. The report was expected to identify energy problems from a number of different perspectives, to analyze, to gather evidence, to synthesize and come up with imaginative suggestions and short term/medium term/ and long term recommendations.

Assessment mechanisms

Students were encouraged to reflect on the common scholarly qualities and characteristics as identified in literature (e.g. [8], [9]) by which appropriate learning standards and criteria were developed in consultation with the students to guide them to achieve their learning objectives. The list of criteria is given in Table I. Students were invited to make judgments about the extent to which they met those criteria and standards for further group discussions in the process of determining what were good case study reports which required them to consider the characteristics of a good progress report. Timely, structured, consistent and informative feedback, and suggestions about techniques to improve student performance, were provided from a range of sources (self, peers, group, and lecturer).

A reflective portfolio was used to encourage students to identify their own strengths and weaknesses, to reflect on their own performance and learning, to take notice of the feedback they received and to be systematic in using this information, and in addition to make a commitment to attend to these issues in future tasks.
These assessment approaches were aligned with the learning objectives for the subject, following the principles suggested by Biggs [10]. Table II shows the link between assessment tasks and learning objectives. Self-assessment, peer assessment, group assessment, class assessment, and lecturer assessment were a variety of approaches for assessment and feedback. We recognized that it was challenging to assess portfolio and case study reports on the quality of the written work. Case studies allowed students to recognize how they had addressed the various elements of the assessment criteria (e.g., evidence of originality, critical review of existing literature, knowledge creation, integration and application, development, selection of an appropriate approach from analysis and evaluation of alternative solutions). Academic reading and writing, and making the connections between the two, are complex processes which students were expected to demonstrate, drawing coherent conclusions from all of the sources. A final semester examination was relatively objective in assessing the basic design and analysis of energy conversion systems.

Evaluation

Multiple evaluation methods were used to indicate the effectiveness of the approach in assisting and enhancing student learning. These included student surveys, to assess students' perception on different aspects of the subject. Student interviews, focused on students' perceptions on what they had learned. Student portfolios focused on their reflective practices.

Conclusion

Our evaluation of the learner-focused approaches in teaching Energy Conversion was done to improve learning outcomes. In conjunction with our own experiences and analysis of both portfolio and case study, together with student interviews, and feedback results from the CLT questionnaire, we formed a clear picture of the effectiveness of the subject:

- Students commented positively on their experience of team working and team learning,
- Students who requested similar approaches in their subjects approached colleagues in the Faculty.
- On the other hand, it was clear that some students found the early experiences in the groups unsettling. As a result, we now recognize a need to spend more time on developing student confidence and expertise in-group work, both in prerequisite subjects and in the future offering of the subject.
- Finally, we realized that the subject at early stages of its development in student-focused learning and teaching mode is time intensive. Effective outcomes from students learning depend on continuous consultation, attention, and prompt response and feed back especially outside of class hours. However, it is expected that this early stage concern to be resolved, after gaining more experiences in student-focused learning and teaching.

Future works

We are currently documenting experiments gained in the developing and implementation of a Web-teaching of an engineering subject and the positive effects in student learning, which will be shared with the engineering community.

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Table I: Qualitative standards for the case study

- Understanding what was required
- Clear goals and objectives.
- Definition, introduction and identification of problems.
- Adequate preparation, wider search, evaluation, justification and significance of the case study objectives.
- Appropriate methodology for investigating and resolving the problem, and making comparisons
- Significant results through exploring the full potential range of solutions.
- Reflective critique, learning from mistakes and misconceptions.
- Effective oral and written presentation.
- Contribution in improvement and education of both self and team members. Co-creation of innovative ideas in team.
- Participating actively in debates with stimulating comments and suggestions.
- Challenging team members with ideas and helping them to apply those ideas in their case study.

Table II Assessment tasks used to achieve learning objectives

Assessment techniques	**Learning objectives**
➢ Case study project ➢ Seminar presentation ➢ Regular written reports. ➢ Reflective portfolio	Skills practiced in real life (e.g. time-management, and self-discipline) Problem formulation, research widely and problem solving Communication skills Reflection, critical thinking and questioning Application of knowledge Organization and structure Comprehension of main idea Research methodology Creativity, innovation, and originality
➢ Self and peer assessment	Basic self management Independence and self monitoring Evaluate their decisions in terms of theory Understand concept and checking data Responsive feedback Professional skills such as (Critical thinking, judgement and evaluation, decision making, and team working Recognize good and poor application of principles

Table III. Student feedback survey to evaluate the effectiveness of the course (no of responses: 34): Percentage Strongly agree (SA), Agree (A), Neutral (N), Disagree (DA), Strongly disagree (SD)

Survey Questions	**SA %**	**A %**	**N %**	**DA %**	**SD %**
Class discussion was a valuable part of the course.	30	42	18	9	0
Exercises which required me to reflect on my own experiences made the subject more relevant.	38	50	9	3	0
Students were encouraged to learn from each other	44	53	3	0	0
The methods of assessment used were appropriate for the subject	12	61	9	12	6
There were sufficient opportunities for students to pursue areas of interest in the subject	42	45	9	0	3
Group activities assisted my understanding	24	48	21	6	0
The case study was a valuable part of the subject	55	39	6	0	0
Assignments encouraged me to read widely	36	58	6	0	0
It would be possible to pass this subject by just working hard around exam time.	9	3	9	24	56
All thing considered, I rate this subject flexible.	39	24	27	6	3