GREENING THE ENGINEERING CURRICULUM: A CASE STUDY FROM ELECTRONICS AND COMMUNICATION STREAM

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This study deals with the experience of introducing a course on ecology and environment to the students of electronics and communication engineering at National Institute of Technology, Srinagar, India. The course was introduced in seventh semester. After completion of the semester the students were provided with a questionnaire regarding the relevance of the curriculum. An overwhelming number of students found the course relevant. Majority of the respondents felt that their perspective towards environment and electronics industry has changed. They became aware of the environmental and health issues associated with various processes and products of semiconductor and information and communications industry. The students developed valuable insights about lifecycle thinking, minimization of waste and optimising the resource usage among others. Majority of the students felt that similar discipline specific course should be introduced in all branches. The course was introduced with the objective that engineering students who are taught to incorporate green engineering into their work will help its implementation in industry.

Keywords: Green engineering, Curriculum, Sustainability, Energy, Pedagogy

INTRODUCTION

Green engineering could be thought of as the transformation of existing engineering disciplines and practices to those that lead to sustainability (Slater et al., 2007). Greening the engineering curriculum is an important consideration to foster sustainable thinking in graduate engineers. The basic principles of green engineering include life cycle thinking in designing engineering products, minimization of depletion of resources including energy, minimization of waste generation etc (Ritter, 2003). A new paradigm in greening the curriculum has evolved. It is an emerging philosophy which aims to protect environment by inventing new engineering processes that do not pollute. It is different and more fundamental than environmental engineering courses which focus on the study of pollutants and their cleanup processes. Several universities across the globe are going for green design concepts in chemical engineering curriculum (Slater et al., 2007). In few universities the green concepts are integrated in all courses whereas in others one or two specific green courses are introduced. While the former is more challenging though appropriate approach, the latter is more prevalent practice due to various constraints.

In India also, several initiatives have been undertaken in various engineering colleges across the country in introducing sustainability concepts. Notable among which is the introduction of sustainable architecture or green architecture in civil engineering stream in many colleges. Moreover courses on renewable energy and energy conservation are taught for quite some times in electrical, electronics and chemical engineering branches. The growing concerns over the e-waste management and the presence of hazardous chemicals in electronic goods is the motivating factor which led to the design of a green curriculum for engineering graduates of electronics and communications stream at National Institute of Technology, Srinagar. The budding electronics and IT engineers need to realise that the manufacturing process in semiconductor industry is highly energy intensive. We are living in an electronic age. We have e-mail, e-banking, e-business, e-books, e-medicine (telemedicine) and so on. The e-products like laptops and cellular phones have penetrated the society in a big way. The day today usage of e-products consumes a lot of electricity, the generation of which is responsible for emission of GHGs in the environment. Moreover all these products and activities is depleting natural resources and adding to the generation of gargantuan waste. Engineering students need to be appreciative about the in-built obsolescence in many products by industrial and market forces. The engineers and the industry must be sensitised to design energy efficient, safer products with longer lifespan and recyclability potential. The best way to achieve this objective is through introduction of sustainability concepts in electronics curriculum. The learning is expected to prepare students to design, explain, promote and implement strategy for bringing sustainability culture into electronics and communications industry (Blackburn, 2007).

Discussion of the Curriculum

At National Institute of Technology, Srinagar semester system is followed and the graduate engineering curriculum consists of eight semesters, leading to a Bachelors of Technology degree. The curriculum of first two semesters is common to all disciplines. During each semester student are expected to take 6-8 courses distributed over about 25 credits. There is now a growing consensus in academia and industry towards sustainability concepts which focuses on respect for people and other form of life (Blackburn, 2007). Previously the only course with a green shade had been on renewable energy at fourth semester level. Several of the environmental problems being faced by humankind are directly or indirectly caused by energy extraction, conversion and utilisation. Therefore a synergy between energy and environment education is needed. The students should be made appreciative of the energy-environment nexus and develop holistic solutions to ensure sustainability. The three credit compulsory course designed and introduced by the author in electronics and communications stream is entitled as 'Ecology and Technology Development'. Few initial lectures were devoted to understanding the importance of technology for growth and development. It is followed by development, dissemination and management of new technologies and integrating people with technology. Next few lectures were devoted to ecological imbalance, emission from technology development and dissemination, emissions reduction, clean development mechanism, carbon credits, carbon trading, prototype carbon fund etc. Main part of curriculum consists of technological interventions to mitigate climate change, design of electronic devices for energy conservation, advances in solar cell and fuel cell technology, system design, e-products in usage and beyond, effective e-waste recycling and management, green electronics, case studies etc. (complete contents of the curriculum are available on the website of the Institute, http://www.nitsri.net).

Methodology

The active and participatory learning method has been used in the coverage of entire course. The class consisted of 45 students. They were divided into nine groups of five students each. Every group was given an issue of concern to ponder upon. They were encouraged to gather materials from books, magazines and internet. In particular magazines like Down to Earth, Terragreen and Hindu: Survey of Environment were used as background reading materials to maximize the learning from the course. These magazines and report discuss latest environmental issues in an Indian context. The class was asked to read 'Green Electronics Survey' report conducted by Greenpeace organization (http://www.greenpeace.org). The students need to be made aware about the latest issues regarding environment and green technologies. Some of the assigned

reading topics included carbon capture and sequestration, efficient lighting systems, the challenges and opportunities in designing solid state lighting systems, development of formal electronic recycling sector, directives on restriction of hazardous substances, smart grid, efficient electronic firewood cooking stove etc. It was made clear in the very beginning that any education on environment and ecology is also about individual integrity and accountability. This means every student had to work on the given assignment on their own.

During mid-term appraisal each group was asked to make a presentation on the assigned topics. The other groups were encouraged to raise issues and challenges on the solutions provided by a particular group. Group discussions were conducted on CFL versus Incandescent lamp. The other debate was on electronic ballast versus conventional ballast. Group discussions were also conducted on the thought provoking questions raised by other students. Every student was encouraged to participate in discussion. The student's performance was assessed through two mid-term and one end term examinations. The weightage of oral presentation was 10%. During each of the examinations their critical thinking was assessed. This is because there are no clear cut solutions to the environmental challenges as compared to technical challenges. Environmental solutions always involve trade-offs (Miller, 2004). In one of the assignments students were asked to design a sustainable township in the year 2050. The responses were highly creative and interesting. The students got initiated in technology forecasting and futuristic design. Several of the students appreciated this particular assignment.

Teaching Learning Materials

Being a new interdisciplinary area, education of green electronics largely suffers from the unavailability of appropriate resource materials for teaching learning. Textbooks are not available for the designed course. For the latest developments in several topics, web particularly Wikipedia was useful. For topics related to global environmental concerns the booklet designed as a course material for Energy Auditor's examination by Bureau of Energy Efficiency, Ministry of Power, Government of India was used. For efficient and effective implementation of education programme in green electronics, it is essential that suitable curricula and textbooks be developed.

Feedback Survey

Before end term assessment students were provided with a questionnaire to get the feedback. There were only three questions and the students were instructed to give candid and precise responses. The questions were:

1. *Do you find the course relevant?*

2. Was the curriculum adequate? If not, suggest any inclusion or deletion of topics.

3. Was the coverage sufficient? If not suggest some way of improvement.

BACKGROUND OF SAMPLE

The students participating in the feedback survey had a diverse background in terms of mother tongue, culture, medium of education and level of family income. Due to admission policy of the National Institutes of Technology, students belonging from various provinces of India join the Institute. About 50% of the students belong to Jammu and Kashmir province and the rest come from other provinces of the country. The proportion of female students is poor in general. It is only 6% in ECE stream. The students are selected on the basis of a national level entrance test and the number of students belonging to a particular province is fixed. Majority of the students came from English medium where as some of them came from vernacular medium. At +2 level, the students faced various boards of examination. Majority of students faced their state boards while some faced Central Board of Secondary Examinations.

ANALYSIS OF RESPONSES

Initially the students were a little apprehensive about any course on ecology as there is a general perception that ecology and environmental education pertains to chemical and civil engineering streams only. Moreover they wanted some core electronics and communication course in final year of their study. However by the time we reached mid semester, majority of the students started appreciating the course. Since I wanted this course to be student centric, a feedback survey was conducted before end semester examination for future improvement of the course.

As regards the questionnaire, there was overwhelming consensus regarding the relevance of the course. Over 92 % of the students wanted it as a separate course. About 4 % students suggested that the concept should be integrated as sections, chapters or modules in all courses wherever relevant during entire eight semesters. A 12% of students were of the opinion that it should be introduced in an earlier semester and in all streams. Regarding the adequacy of the curriculum about 6% of respondents wanted incorporation of environmental laws, regulations and policies of India. It was a good suggestion and may be considered during next board of studies meeting. About 4% students wanted inclusion of study on radiation hazards and safety measures. Regarding the coverage part 8% students wanted more brain storming sessions in the classroom.

CONCLUDING REMARKS

The student's response to the feedback survey has been quite encouraging. The board of studies has been duly informed of the suggestions made by the students. It is hoped that the green engineering may become a central component of engineering curriculum across all discipline in coming times. The engineer as the designer of products and processes has a central role in designing processes that have a minimal impact on the environment. Using the green engineering principles at the design process can lead to products and processes of a sustainable future. The active and participatory learning method adopted in curriculum delivery on Ecology and Technology Development will induce transformation in thinking, values and actions required for a shift towards sustainability concept (Wald, 2007). The students who have developed insights in environmental issues will try to infuse sustainability concepts into business organizations they will join in future.

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