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EDUCATION FOR SUSTAINABLE DEVELOPMENT: ASSESSMENT OF THE CURRENT SITUATION AT THE FACULTY OF ENGINEERING OF NOTRE DAME UNIVERSITY – LOUAIZE

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Abstract

There is a growing need to incorporate educational sustainable development (ESD) principles into engineering education. This paper identifies engineering competencies within the Faculty of Engineering at Notre Dame University – Louaize and the means to shift towards sustainability. ESD tools are used to carry the analysis, keeping in mind the Faculty of Engineering accreditation system ABET, incorporated as the Accreditation Board for Engineering and Technology, Inc., requirements. A survey of the current situation was conducted based on seven key areas: curriculum, research and scholarship, operations, faculty and staff development, outreach and service, student opportunities, administration, mission and planning. The survey revealed some weaknesses that the Faculty of Engineering needs to address for a successful implementation of sustainable practices. ESD is integrated in two selected engineering courses. At the beginning of the course, a questionnaire is used to assess the knowledge, behaviour and attitudes of students. Results show that students currently understand the importance of ESD, but they have a weak knowledge of the relationship between the environment and sustainable future and a bad understanding of sufficient living economy principle. The analysis showed also the need to introduce new courses of sustainability. Nevertheless, the proposed amendment to the curriculum ought to be carried in conjunction with the Faculty of Engineering accreditation system ABET. A wide dissemination of ESD throughout the entire engineering programme will help promoting sustainability. Besides, the infusion of ESD can be implemented within a common engineering course – a mandatory course for all engineering students following ABET amendment procedures.

Key words: *engineering, education, curriculum development, sustainability, competences*

Introduction

The world is facing current and future environmental and social challenges. Over the past decade, sustainability strongly emerged as the new paradigm of development. Climate change, energy resources, water scarcity, air and water pollution are among the new challenges for humanity. In this context, higher education can be the tool for achieving sustainability (United Nations Educational, Scientific and Cultural Organi-

sation [UNESCO], 2006). The institution of higher education is the central forum where leaders and decision makers can exchange views (Bekessy, Burgman, Yencken, Wright, Filho, Garden, & Rostan-Herbert, 2002). Therefore, profound changes in higher education programmes are necessary to integrate the concepts of sustainability in the programmes and prepare the new generations to deal with a rapidly changing and less predictable global system (Sipos, Battisti, & Grimm, 2008). The reoriented programmes must take into consideration the many and complex facets of local environmental, economic and societal conditions. However, it is a challenging task to redesign curricula to achieve sustainability by preparing graduates with the necessary knowledge and values, a capacity for critical thinking and the motivation to deal with diverse problems associated with unsustainable situations. At the heart of this challenge is the lack of understanding the concept of sustainability as a basis and the need to develop curricula based on concepts related to sustainability rather than the traditional set of concepts related to each discipline (Sibbel, 2009). In order to raise the education for sustainable development to this level, the academic structure of study must be changed to introduce sustainable development as a transversal skill in all majors, defining the skill as the students' capacity to internalise and apply sustainable solutions to all aspects of their professional life: technological, environmental and social aspects.

In this context, Notre Dame University – Louaize (NDU) has engaged in partnership with a number of higher education institutions from Greece, Ireland, France, Jordan, Lebanon and Egypt in a radical reorientation of the curricula in order to enable the new generation of professionals to be more efficient in operating the transition towards a sustainable society and act to influence it. The project, entitled "Reorient University Curricula to Address Sustainability" (RUCAS), consists of developing resources to involve faculty members, review of curricula, capacity building and establish a network for support. The areas of curriculum revision are numerous: educational and social sciences, engineering, information technology and applied sciences. For each discipline, students' competences are developed and will be validated after. The support system consists of an education for sustainable development (ESD) curriculum review toolkit, a virtual centre for curriculum reform in each partner institution and a series of seminars aiming at training faculty members to implement ESD into their own courses. The target is to reach more than 40% of the study programmes to address ESD in every partner institution (RUCAS, 2011).

This paper describes the advances achieved at the Faculty of Engineering of NDU and discusses some ideas for future action. At the Faculty of Engineering, students' competencies to address ESD have been assessed. A survey based on the approaches developed by University Leaders for a Sustainable Future (ULSF) was used to analyse the current situation and to point to some challenges and strategies for integrating sustainability into the curricula (ULSF, 2009). Finally, two engineering courses were selected for a pilot study on infusing sustainability concepts. The students' knowledge, attitudes and skills before attending these courses are measured and will be used to assess the students learning at the end of the course.

Competencies for engineering in addressing ESD

Engineers have a major role to play in the enhancement of sustainable future. Most of these challenges require engineers to be able to design and construct sustainable systems that address current needs, without compromising future generations. Traditionally,

engineers have been at the vanguard of social development. So it is their responsibility to contribute to the solution of food shortage, water management and decent shelter for the world population, while using the least amount of existing resources. This cannot be accomplished using the current conventional techniques. It is true that some little progress in conservation, recycling and awareness has been reached yet. The path to reach the above goal is long if a breakthrough in clean technology is not made soon.

The traditional method of engineering education is deemed to fail if not substantially reshuffled and rethought. The outcome of an extremely slow process of modernisation will certainly create a new revolutionary method of education, transforming the existing to obsolete ones. A holistic approach comprising a wider knowledge base in the social, political and life sciences in addition to physical sciences and mathematics must be entailed (Chau, 2007). However, integrating learning experiences addressing these goals in engineering programmes involves many challenges, including stating operational learning outcomes for sustainability knowledge, skills and attitudes for a particular programme, making a contextualised interpretation of the concept, curriculum design issues, such as creating separate courses on sustainability and integrating such topics in other courses (Wedel, Malmqvist, Arehag, & Svanstrom, 2008). In order to produce the change in this direction, there is a growing interest in the 'competence approach' as change agents to implement ESD, assess the progress of its implementation and advance thinking and practice of cross-boundary transformative sustainability in higher education (Mochizuki & Fadeeva, 2010).

Within the framework of the RUCAS project, there is an opportunity to address students' competence as part of the well-known five general pillars: learning to be, learning to live together sustainably, learning to know, learning to do and learning to transform oneself and society (UNESCO, 2006). However, the project gives each discipline a foundation to develop its own specific set of competencies. In the meantime, the competencies defined for engineers can allow for a more creative educational thinking process.

Certain courses are more prone to incorporate the notion of sustainable development than others. However, introductory courses can include a general knowledge of sustainability and sustainable development in engineering. The objective is to induce all graduates, especially in the fields far from sustainable development (SD), to carry this valuable luggage during their practice and train them to the notion of learning to live together sustainably.

Ethical responsibilities are part of a professional track. Graduates in developing countries have a serious challenge in facing corruption. The awareness of the importance to be dedicated to the professional and ethical responsibilities should be cultivated in the spirits of the emerging generation. Regardless of the type of practice, the first line of defence to counter corruption is the personal virtues related to ethics. Nevertheless, this skill needs to be nurtured in school, due to its complexity and multiple faces. Engineers will then need to nurture the notion of transforming themselves and their entourage in order to inculcate ethical behaviour around.

Engineers have always been dealing with leadership skill. The type of engineering profession does include design and execution. The execution part is mainly a skilled management process. Academic engineering programmes aims at building up future leaders, cultivating the notion of leadership skills for sustainable engineering design to counter-balance the loss of our resources.

In designing systems, engineers need to promote the application of environmentally friendly technology versus resource intensive technology that used to pollute, create

social injustices and disrupt communities. Eco-friendly solutions are given priority in industry research and development, as well as academic research. Use of the techniques, skills and modern engineering tools necessary for environmentally sound engineering practice needs to be given priority in teaching to live together sustainably.

Several engineering schools are seeking programmes' accreditation from the Accreditation Board for Engineering and Technology (ABET), either in preparation for a first assessment or renewal. Per ABET standards, designing a system, component or process to meet desired needs is achieved within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability (www.ABET.org). Learning to know and to conceive such system needs to be imbedded within our teaching.

Teamwork is also the issue to be promoted within ABET guidelines. Working in multidisciplinary teams in engineering practice is also encouraged among students to adapt current technology to sustainable lifestyles. This effort is mainly pursued among senior students developing their final year projects. Their teaming together is a means to learning to do things together with joint efforts and combat individualism and selfishness.

While engineering education gets busy focusing on technical features, the system often encourages faculty and students to omit addressing the global picture of understanding the impact of technology on society and nature and learning to transform oneself and society. This is mainly due to the type of teaching cloistered within classroom walls. Besides, understanding how different cultural, social and political contexts impact design is also part of the technical teachings. It also includes the analysis of the impact of engineering and technology on individuals, organisations and society, including ethical, legal, security and global policy issues after implementation. Engineering education needs to incorporate the formation of future engineers capable of listening closely to the demands of citizens and other stakeholders, in order to let them have a say in the development of infrastructures. Also the discussion of social and psychological aspects of environmental behaviour change (for instance, why and how people change or do not change) in relation to engineering practices is useful. Finally, engineering students should be introduced to the United Nations Millennium Development Goals at an early stage, as being the framework to plan their future. The engineering educational system which is unsuccessful in training its students to become visionaries is a stagnant one doomed to failure.

Current situation at the Faculty of Engineering at NDU

Within the framework of the RUCAS project, the Faculty of Engineering has conducted a study to investigate and understand the current practices and policies related to sustainability. The aim was to document the environmental sustainability of teaching, research and operational practices at the faculty level. A questionnaire survey based on the approaches developed by ULSF has been carried out. Seven key areas were examined: curriculum, research and scholarship, institutional operations, faculty and staff development and rewards, outreach and services, students' opportunities and institutional mission and structure. The main outcomes of the assessment show the following:

Curriculum. The programme includes several courses related to sustainability. Most of these courses are offered by the Department of Civil and Environmental Engineering. Undergraduates are required to take more than one course on issues related to environ-

mental engineering or sustainability. However, the number of courses addressing sustainability compared to the total number of offered courses is relatively small. Minimum effort is made to educate students about the role of the institution in its social and ecological systems.

Research and scholarship. It is roughly estimated that around 20% of faculty members are doing research on sustainability issues. The estimated percentage of faculty members that would be interested in doing more teaching and research is considered to be around 50%. Examples of research activities in this area are journal and conference articles on water pollution and on integration of renewable energy in buildings. The Faculty of Engineering has also an affiliated research centre, the Water Energy and Environment Research Centre, which aims to investigate the water and energy resources and the state of environmental situation in Lebanon and the Middle East and North Africa region. However, the interaction between the centre's activities and the students' education at the Faculty of Engineering needs to be strengthened for a better interaction among disciplines and for facilitating interdisciplinary research. Public policy issues in particular are not considered to be well addressed by the Faculty of Engineering.

Operations. Current practices at the Faculty of Engineering in terms of implementing sustainability in operations are very limited. A campus energy audit and proper retrofits are inevitable. Although some recycle bins for papers do exist, they are not efficiently used, the cleaning staff lack awareness and training. Indeed, many of them are usually collecting and mixing papers with the regular trash. However, few signs showing the commitment of the Faculty of Engineering to sustainability can be visualised at NDU. They include green space and trees, recycle bins and non-smoking signs inside buildings. But many current practices show unsustainable behaviours: lots of cars on campus, lights left on in empty classrooms and offices, students smoking inside buildings and inadequate heating and cooling regulation within the edifice. In general, there are very few efforts to integrate operational practices related to sustainability into educational and scholarly activities. A recent project consisted of designing a sustainable extension to the Faculty of Engineering building and laboratories. In this project, the staff from physical plant worked directly with students.

Faculty and staff development and rewards. Current criteria for hiring and promotion for faculty are mainly focused on teaching, scholarships and services. Sustainability is only explicitly considered as a criterion for some relevant positions, such as the need to recruit for an environmental engineering faculty member at the Department of Civil and Environmental Engineering. In recruiting or promoting staff, the contribution to sustainability is not directly recognised. Professional development opportunities to enhance understanding, teaching and research in sustainability do exist. Seminars and conferences are organised by the students' chapters of engineering professional societies, in addition to the distribution of available soft and hard copies of journals of renewable energy, energy efficiency and movies on sustainable construction and air pollution.

Outreach and service. Few examples of partnership between the Faculty of Engineering and other local and international faculties and organisations exist. The participation of the staff in a European project on renewable energy in developing countries (Ressol-Medbuild) can be cited. Also the staff are teaming up at the university level with other colleagues in reorienting the programmes to address sustainability, in collaboration with international partners, and the RUCAS project is a vivid example. The Faculty of Engineering also participates occasionally in organising conferences on sustainability.

A conference on renewable energy for developing countries is a recent example (www.ressol-medbuild.eu). Raising awareness through participation in public events can also be viewed as an important activity to serve the community (www.cbd.int/idb/2012/celebrations/lb/).

Students' opportunities. Students' chapters of international professional engineering societies promote sustainability by organising students' events and inviting speakers on campus to address environmental issues. The extent of involvement of student groups in sustainable initiatives is dependent on the interests of the executive committees and their mandates.

Administration, mission and planning. Sustainability is an integrated part of the mission and vision of the Faculty of Engineering. Yet, the Faculty is not clearly implementing sustainability in its strategic planning. The Faculty of Engineering needs to reinforce its commitment by first acting as a role model to students and creating, for instance, a task force in place to facilitate sustainability or by dedicating some positions for sustainable practices. Current visibility of sustainability in the Faculty of Engineering is limited to organising seminars, inviting guest speakers and projecting target movies on environmental topics.

Finally, the building of the Faculty of Engineering is a negative example for energy efficiency and green construction and represents a weakness in terms of educating for sustainability. A green renovation needs to be planned in order to offer students a live demonstration of sustainability.

Pilot study: Infusing sustainability into two engineering courses

Sustainability can be viewed as a woven focus of engineering education compared to other disciplines. Therefore, the Faculty of Engineering is in a strategic position to play an important role at the university level in that area. Engineers with environmental background are a valuable asset to the Faculty of Engineering. The best way to prepare engineering students for a sustainable future is to provide them with a fundamental education in basic sciences, engineering fields, society and the important systemic understanding of the broad linking amongst them (Chau, 2007). Redesigning the curricula at the Faculty of Engineering to incorporate sustainability is not an easy task, since the existing one is very condense, and the addition of new material might require sacrificing other essential material. The shift in the programme should be made in a way to introduce sustainability concepts in a generic manner. The students should be made aware of the significance of environmental constraints in any design activity.

Within the framework of the RUCAS project, the chosen strategy by the Faculty of Engineering is to infuse appropriate sustainability concepts into existing courses. Two typical courses were selected first for a pilot study: the study course "Soil Mechanics, an Introduction to Foundation Engineering" and the study course "Concrete Design".

Traditionally, the study course "Soil Mechanics, an Introduction to Foundation Engineering" used to incorporate applications related to structural foundations. To infuse sustainable development, examples from groundwater and soil pollution are introduced. For instance, hydraulic conductivity of soil is now related to the propagation of pollutants in soil and groundwater, with discussions on the methods of remediation. A part related to geohydrology covers applications on water management, such as dams and groundwater wells.

The course "Concrete Design" is conventionally oriented towards the safety and the economy of the design. A research-based project on sustainable concrete material and/or techniques is added to the course to provide students with the opportunity to learn about alternative sustainability principles that can be applied to engineering design.

A questionnaire developed for the RUCAS project was used to survey the students' knowledge, understanding, attitudes and skills at the beginning of the two courses, using a 5-level score (highest = 5, medium = 3, lowest = 1). The questionnaire tries to investigate five main topics: environment and its relationship to sustainable future; consumption and sufficient living; good citizens in democratic society; value of different cultures and education for sustainable development.

The questionnaire was distributed to 71 students during the first lecture. The analysis of the results of the first forms revealed that medium to low score was obtained for the part on the relationship between the environment and sustainable future (Figure 1) and medium to low score was also recorded on the part of sufficiency principle. Medium to high score was obtained for the democratic society and the cultures of other societies parts; medium to high score – for the ESD part.

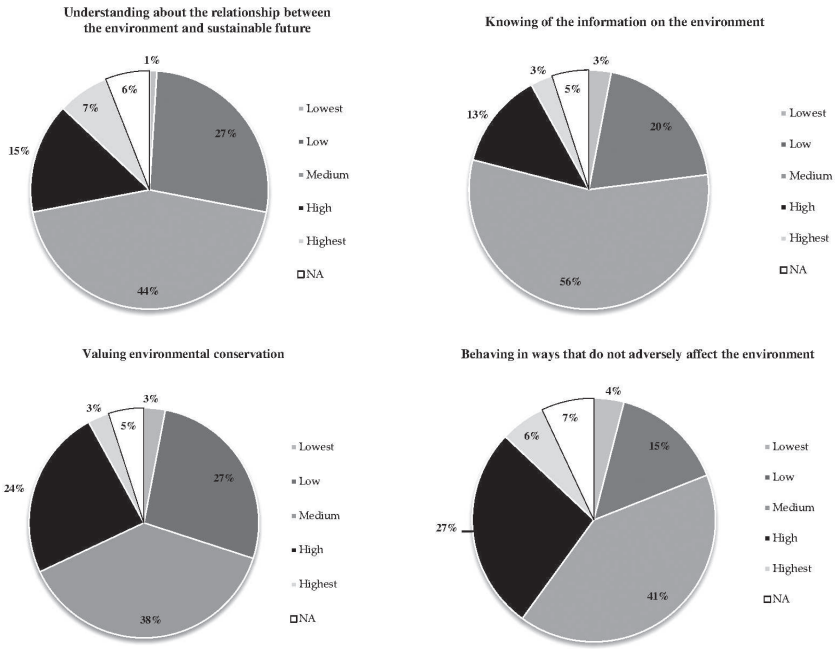

Figure 1. Results of questions surveying students' knowledge and skills of the environment

Therefore, we can estimate that there is a need to focus on a better integration of environmental knowledge, values and ideas in the selected courses and to develop a prerequisite course that introduces the students to this topic. Another focus should be the integration on the concepts for sufficiency of living economy principle. As for the parts related to democracy and respect of other cultures, the score can be explained by the multiethnic nature of the Lebanese society, where the cultural interaction between 18 religions is very dynamic and the relatively democratic nature of the Lebanese system.

The result concerning ESD is a good sign that shows an acceptable level of students' awareness of the importance of sustainability in education and their willingness to acquire the skills needed for SD. The challenge for the faculty is in developing the courses and the teaching methods of these concepts. To assess this first step, the same questionnaire will be redistributed at the end of the course to the same sample of students. This will help to evaluate the degree of success or failure of the infusion of sustainability in the selected courses and to fine tune the method used for a better infusion in a wider pool of engineering courses.

Conclusion

Most of the traditional engineering curricula are designed to provide students with a strong scientific knowledge, focusing mainly on the safety and efficiency of design, and the Faculty of Engineering of NDU is not an exception. However, this approach in engineering education is deemed to fail if not substantially reshuffled and rethought. Some courses related to sustainability are offered in the programme of the Faculty of Engineering, but they do not form an integrated part of the undergraduate education. The need to incorporate better the sustainability concepts within the curricula is a major concern to the Faculty of Engineering which is also seeking the ABET accreditation. Within the framework of the RUCAS project, the infusion of the principles of sustainable development into engineering education has been started at the Faculty of Engineering and will be improved and expanded in the near future, taking local and regional characteristics into account. A survey of the environmental sustainability of teaching, research and operational practices at the Faculty of Engineering reveals many weaknesses and shows that there is a need to revise the current practices and policies related to sustainability. The analysis of the questionnaire that was filled in by the students shows that in addition to infusing sustainability concepts, there is a need to develop a new core course that introduces the engineering students to the basic environmental knowledge, values and ideas. In conformity with ABET requirements, the course will be developed as a result of extensive students feedback, rubrics analysis and outcomes, alumni and employers feedbacks.

To conclude, NDU along with its partners in the RUCAS project has the opportunity to lead the way in developing the strategies and tools for infusing sustainability concepts in education and to provide a benchmark for other Lebanese Universities. The work described here is only a part of long on-going process at NDU to encourage ESD.

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