The Integration of Environmental Educational Outcomes within Higher Education to Nurture Environmental Consciousness amongst Engineering Undergraduates

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Abstract—Higher education has an important role to play in advocating environmentalism. Given this responsibility, the goal of higher education should therefore be to develop graduates with the knowledge, skills and values related to environmentalism. However, research indicates that there is a lack of consciousness amongst graduates on the need to be more environmentally aware, especially when it comes to applying the appropriate knowledge and skills related to environmentalism. Although institutions of higher learning do include environmental parameters within their undergraduate and postgraduate academic programme structures, the environmental boundaries are usually confined to specific engineering majors within an engineering programme. This makes environmental knowledge, skills and values exclusive to certain quarters of the higher education system. The incorporation of environmental literacy within higher education institutions as a whole is of utmost pertinence if a nation's human capital is to be nurtured to become change agents for the preservation of environment. This paper discusses approaches that can be adapted by institutions of higher learning to include environmental literacy within the graduate's higher learning experience.

Keywords—Higher education, engineering education, environmental literacy, Malaysia.

I. INTRODUCTION

THE term 'environmental literacy' was first introduced by Charles E. Roth in the year 1968. It is the ability of an individual to comprehend the fundamental philosophies of the ecosystem and act accordingly so as not to harm the environment. Disinger and Roth define environmental literacy as the ability to construe the wellbeing of the environment and

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take the necessary measures to uphold it [1]. Roth, in his revolutionary report *Environmental Literacy: Its Roots, Evolution and Directions in the 1990s* further notes that environmental literacy is drawn upon main areas such as 'environmental sensitivity', 'knowledge, skills, attitudes and values', 'personal investment and responsibility' and 'active involvement' [2]. The environmental literacy framework developed by Deborah Simmons for the North American Association for Environmental Education outlines 'ecological knowledge', 'socio-political knowledge', 'knowledge of environmental issues', 'cognitive skills', 'affect', 'environmentally responsible behaviour' and 'additional determinants of environmentally responsible behaviour' as important categories [3]. Underlying the definitions and descriptions of environmental literacy is the important role that education plays in putting forth the environmental consciousness agenda. Environmental consciousness and environmental literacy go hand in hand with environmental education. In discussing the role of environmental education, it would only be appropriate to deliberate upon the importance of including environmental literacy as an important goal for all levels of education be it primary education, secondary education or higher education. However, as the intent of this study is focused upon higher learning, the discussion on environmental literacy will be confined to the context of higher education. This paper discusses a Malaysian private higher education institution's integration of environmental educational goals, which serves the purpose of developing environmentally conscious graduates who will be able to contribute to the betterment of their society and nation. The focus of the paper will be the higher education institution's undergraduate engineering programme, specifically the manner in which environmental consciousness is developed amongst its undergraduate engineering students.

II. THE ROLE OF HIGHER EDUCATION IN ADVOCATING ENVIRONMENTAL CONSCIOUSNESS

Environmental literacy is key to the nurturing of environmental consciousness within higher education. As a result, higher education has an important task in ensuring that environmental educational outcomes are upheld within its academic programmes. In aiding universities to integrate environmental educational outcomes within its academic

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programmes, UNESCO's value driven aims provide an initial set of guidelines to forward the environmental agenda within universities. The UNESCO guidelines are as stated below:

1. 'Respect for the dignity and human rights of all people throughout the world and a commitment to social and economic justice for all
2. Respect for the human rights of future generations and a commitment to intergenerational responsibility
3. Respect and care for the greater community of life in all its diversity, which involves the protection and restoration of the Earth's ecosystems
4. Respect for cultural diversity and a commitment to build locally and globally a culture of tolerance, non-violence and peace' [4: p2]

In addition to this, universities throughout the world have also joined forces to pledge their dedication towards the environment through several declarations. Three key initiatives are highlighted here, i.e. the *Talloires Declaration*, the *Kyoto Declaration* and the *University Charter for Sustainable Development*. The *Talloires Declaration* is an action plan that was conceived through the United States based University Leaders for a Sustainable Future (ULSF) and carried signatories' commitment 'to establishing programmes for environmentally responsible citizenship, to teaching environmental literacy to all undergraduate, graduate, and professional students, and to developing interdisciplinary approaches to curricula, research initiatives, operations, and outreach activities' [4: p. 3]. Through the *Kyoto Declaration* , it was agreed upon that universities would agree 'to develop university capacity to teach, research, and take action according to sustainable development principles, to increase environmental literacy, and to enhance the understanding of environmental ethics within the university and with the public at large') [4: p. 3]. The *University Charter for Sustainable Development* also forwarded the need for environmental aspects to be included in the curriculum, teaching and learning activities of universities, i.e.

> Universities shall incorporate an environmental perspective in all their work and set up environmental education programmes involving both teachers and researchers as well as students – all of whom should be exposed to the global challenges of environment and development, irrespective of their field of study…Universities shall encourage interdisciplinary and collaborative education and research programmes related to sustainable development as part of the institution's central mission.
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> [4: p. 3]

The *Talloires Declaration*, the *Kyoto Declaration* and the *University Charter for Sustainable Development* initiatives are evidence that higher education plays a significant role in advocating environmental consciousness amongst university graduates. The integration of environmental educational outcomes within higher education is therefore necessary if a country is to nurture environmentally conscious graduates. Environmental consciousness can be approached in a myriad of ways within higher education. The most common methods are through the teaching and learning process as well as research. Environmental consciousness educational goals have been successfully included in the undergraduate and postgraduate curriculum in many countries in the world, with the most common method being its introduction as a programme major at the undergraduate level or as a specialization at the postgraduate level. Three models which have been used to develop the green agenda through higher education are highlighted here.

Model 1: Curriculum Greening of Higher Education

The Curriculum Greening of Higher Education model was developed in Spain. The development of the model involved 11 European and Latin American universities. Characteristics of the model are as listed below:

1. Integrating the paradigm of complexity into the curriculum
2. Introducing flexibility and permeability into disciplines
3. Contextualizing the curricular project
4. Taking the subject into account in the construction of knowledge
5. Considering the cognitive, affective and action aspects of people
6. A consistent relationship between theory and practice
7. Working within a prospective orientation of alternative scenarios
8. Methodological adaptation: new teaching and learning methodologies
9. Creating space for reflection and democratic participation
10. Reinforcing the commitment to transforming relations between society and nature

Model 2: Integral University Approach

At the Technical University of Catalonia in Barcelona, the inclusion of environmental aspects in technical education is done through an 'integral university approach' which merges concurrent action in education, research, university life and communication for the development of a model that is synergetic [6]. In expediting the change of the university towards a greener one, the creation of useful tools for decision making, the introduction of environmental indicators into university processes, and assessment of change through environmental research maps were established. In Cardiff University, green issues are addressed as a 'portfolio' where the schools rely on compartmentalization, over-specialization, and reductionism' [7: p. 643]. Using this approach, schools excel within their own disciplines and to a particular green dimension.

Model 3: Reorientation of Existing Curriculum

Environmental consciousness can also be approached via the reorientation of existing curriculum. Using engineering programmes as an example, Crofton suggests focusing on

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green issues, problems, and/or solutions in which engineers may be involved or may be expected to contribute [8: p. 404] as a method to promote green thinking amongst students. Huntzinger, Hutchins, Gierke and Sutherland advocate the use of student-centered, problem-based learning and deep learning as a means to promote green thinking in undergraduate engineering students [9]. Segalàs, Ferrer-Balas and Mulder recommend lecture sessions, project-based learning, case studies, problem-based learning and role-play as some of the strategies that can be used with students [10].

III. THE INTEGRATION OF ENVIRONMENTAL CONSCIOUSNESS IN UNIVERSITI TEKNOLOGI PETRONAS (UTP)

In the Malaysian higher education context, environmental nuances have been projected at the undergraduate and postgraduate levels mostly through engineering programmes. Environmental goals are usually included at the programme outcomes and course outcomes level. This is due to the fact that Malaysian institutions of higher learning offering engineering programmes are required by the Malaysian Engineering Accreditation Council (EAC) to ensure engineering programmes include programme educational outcomes related to the environment. The EAC outlines a total of 11 outcomes, of which outcomes number 3 and 7 are specifically address the need for engineering graduates to be environmentally conscious. This is apparent through the use of phrases such as *environmental considerations* and *environmental contexts* in outcomes 3 and 7 respectively. The EAC criteria are as listed below:

1. Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialisation to the solution of complex engineering problems
2. Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences
3. *Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations*
4. Conduct investigation into complex problems using research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions
5. Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations
6. Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice

7. *Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development*
8. Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice
9. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
10. Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
11. Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. [11:2-3]

As a private Malaysian university offering engineering programmes at the undergraduate and postgraduate levels, UTP's structured approach in translating the EAC's environmental outcomes into the undergraduate engineering programmes outcomes has resulted in its engineering programmes being given the necessary accreditation by the council. The university's approach towards the integration of environmental consciousness within the academic context is apparent at two levels, i.e. the engineering programme outcomes level (Layer 1) and course learning outcomes level (Layer 2). Instances of the university's integration of environmental goals within both levels are now presented.

Layer 1: Programme Level

UTP offers undergraduate engineering degrees in five areas. These areas are Chemical Engineering, Civil Engineering, Electrical & Electronics Engineering, Mechanical Engineering and Petroleum Engineering. Environmental outcomes feature as educational outcomes of every programme. Each engineering programme prescribes to a set of programme outcomes which form the essence of the programme. Upon graduating from their respective engineering programmes, the graduates are expected to have gained the knowledge, skills and attitudes as set in the programme outcomes. Listed below are the outcomes of all five engineering programmes, obtained from the Academic Central Services Department of the university.

Chemical Engineering Programme Outcomes

1. Acquire and apply knowledge of basic sciences and engineering fundamentals
2. Acquire and apply Chemical Engineering principles and in-depth technical knowledge
3. Ability to design, optimize and operate processes
4. Undertake problem identification, formulation and solution by considering the concept of sustainable development

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5. *Comprehend social, cultural, global and environmental responsibilities of a professional engineer, and the need for sustainable development*
6. Communicate effectively in a professional context
7. Exhibit professional and ethical responsibilities
8. Demonstrate leadership, business acumen and entrepreneurship
9. Demonstrate the capacity to undertake lifelong learning

Civil Engineering Programme Outcomes

1. Acquire and apply knowledge of basic civil engineering fundamentals
2. Practice in-depth technical competence in any specific civil engineering discipline
3. Identify, formulate and solve problems using creativity and innovation
4. Utilize systems approach to evaluate operational and maintenance performance and application software
5. Demonstrate the principles of entrepreneurship, sustainable design and development
6. Practice professional and ethical responsibilities
7. Communicate effectively with all levels of industry and society
8. Perform effectively as an individual and in a team with the capacity to be a leader or manager
9. *Demonstrate the understanding of the social, cultural, global and environmental responsibilities of a professional engineer, and the need for sustainable development*
10. Recognize, acquire and possess the need to undertake life-long learning and professional development
11. Analyze and optimize contractual and financial implications on project selections

Electrical & Electronics Engineering Programme Outcomes

1. Ability to acquire and apply knowledge of basic science and engineering fundamentals
2. Acquire in-depth technical competence in a specific engineering discipline
3. Ability to undertake problem identification, formulation and solution in electrical & electronics engineering
4. Ability to utilize a systems approach to design and evaluate operational performance in electrical & electronics engineering
5. Ability to demonstrate the understanding of the principles of sustainable design and development
6. Ability to demonstrate the understanding of professional and ethical responsibilities and commitment to them
7. Ability to communicate effectively, not only with engineers, but also with the community at large
8. Ability to function effectively as an individual and in a group, with the capacity to be a leader or manager, as well as effective team member
9. *Ability to undertake social, cultural, global and environmental responsibilities of a professional engineer*

10. Ability to undertake life-long learning, and possessing/acquiring the capacity to do so
11. Demonstrate business acumen and entrepreneurship in specific engineering, and other related businesses

Mechanical Engineering

1. Ability to acquire and apply knowledge of science and engineering fundamentals
2. Ability to undertake problem identification, formulation and solution in mechanical engineering
3. Ability to acquire in-depth technical competence in a mechanical engineering discipline
4. Ability to utilize systems approach to design and evaluate operational performance in mechanical engineering
5. Understanding of the principles of design for sustainable development
6. Understanding of professional and ethical responsibilities and commitment to them
7. *Understanding of the social, cultural, global and environmental responsibilities of a professional engineer*
8. Demonstrating business acumen and entrepreneurship in mechanical engineering, and other related businesses
9. Ability to communicate effectively, not only with engineers, but also with the community at large
10. Ability to function effectively as an individual and in a group, with the capacity to be a leader
11. Recognizing the need to undertake life-long learning, and possessing/acquiring the capacity to do so

Petroleum Engineering

1. Ability to apply knowledge of science and engineering fundamentals
2. Technical competency in petroleum engineering disciplines
3. Ability to undertake problem identification, formulation and solution in petroleum engineering
4. Ability to utilise systems analysis approach to design and to evaluate performance in petroleum engineering
5. Understanding of the principles of design for sustainable development
6. Understanding of and commitment to professional and ethical responsibilities
7. Ability to communicate effectively, not only with engineers, but also with the community at large
8. Ability to function in a group, with the capacity to become a leader
9. *Ability to undertake the social, cultural, global and environmental responsibilities of a professional engineer*
10. Recognition of the need to undertake lifelong learning
11. Ability to demonstrate business acumen and entrepreneurship in petroleum engineering, and other related businesses

A summary of these goals are presented below:

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- Chemical Engineering - Criteria 5 (1 out of 9 outcomes)
- Civil Engineering – Criteria 9 (1 out of 11 outcomes)
- Electrical & Electronic Engineering – Criteria 9(1 out of 11 outcomes)
- Mechanical Engineering – Criteria 7(1 out of 11 outcomes)
- Petroleum Engineering – Criteria 9(1 out of 11 outcomes)

As evident in the summary, each engineering programme has allocated one criterion specifically related to environmental consciousness. This is evidence of the university's acknowledgement of the importance of environmental literacy for its engineering graduates. It further indicates the university's commitment to environmental consciousness.

Layer 2: Course Outcomes Level

The second layer of the integration of environmental educational outcomes is seen at the course outcomes level. This level depicts the integration of educational outcomes at the course (module) level. The translation of the programme outcomes into course outcomes are shown below using an example of two compulsory engineering courses that all undergraduate engineering students need to take in the second and fourth year of their undergraduate studies. The content of both courses are common to all engineering students, regardless of their engineering major.

Course 1: Health, Safety & Environment

This course is taken during the second year of the undergraduate's four years of study. The learning outcomes of the course are as listed below:

1. *Describe current regulations and law relating to health, safety and environment and the role of engineers and technologists as HSE personnel or employee.*
2. *Evaluate and relate environmental hazards and concerns with regards to key principals of sustainable development*
3. Identify and analyse hazards using hazard identification methods and techniques in the workplace
4. Analyze and assess HSE components in any given case studies, accidents and failures
5. Relate safety issues to the design and operation of equipment to their disciplines
6. Recognize suitable mitigation techniques to eliminate or reduce hazards

Course 2: Engineers in Society

This course is taken during the undergraduate's final year of studies at the university. The learning outcomes are as stated below:

1. Demonstrate the role of Engineers in society according to Engineers' Act 1997
2. Apply basics of Operation and Project Management

3. *Implement requirements of Environmental legislation in projects*
4. Apply basic Quality Management Tools
5. Discuss the business and legal aspects in an engineer's work

As evident in both courses, the environmental goals from all five engineering programmes, i.e. Layer 1 Programme Outcomes have been translated into course learning outcomes i.e. layer 2. In the Health, Safety & Environment course, 33.33% of its learning outcomes are related to the nurturing of environmental consciousness. In the Engineers in Society course, 20% or one out of five learning outcomes aim to develop environmental consciousness amongst the university's engineering undergraduates. The programme outcomes and course outcomes layers are with no doubt, the main levels in which higher education institutions can integrate environmental educational goals within academic programmes. These are the more prominent layers in which environmental educational goals can be made more explicit. UTP is an apt example of such integration. However, there is also a third layer of integration. Layer three denotes the integration of environmental educational outcomes at the course subject matter/topic level. The course subject matter is in reference to the weekly content of the particular course, as presented through lectures, tutorials and laboratory sessions.

IV. Towards a Generic Framework for the Integration of Environmental Educational Outcomes Within Undergraduate Programmes Using the UTP Experience

The section above discussed the different layers in which environmental goals had been integrated in an undergraduate engineering programme in UTP. The discussion encompassed the ways in which the university approached the integration of environmental goals within the programme outcomes level, course outcomes level and subject matter level. The integration of environmental goals within an academic programme can thus be done at these three levels. Using UTP's approach to the integration of environmental goals within an academic programme as an example, an environmental educational outcomes framework is thus outlined in Fig. 1. While there are frameworks that discuss the integration of engineering educational outcomes, to the knowledge of the researchers, there are no frameworks for the integration of environmental educational outcomes using an outcomes approach at the programme outcomes, course outcomes and subject matter levels. This framework thus highlights UTP's endeavor in promoting the importance of environmental awareness and literacy amongst its future graduates. Using this structured approach, UTP's environmental education initiative can thus be emulated and adapted by higher education institutions over the world which wish to embed environmental educational outcomes within its curriculum.

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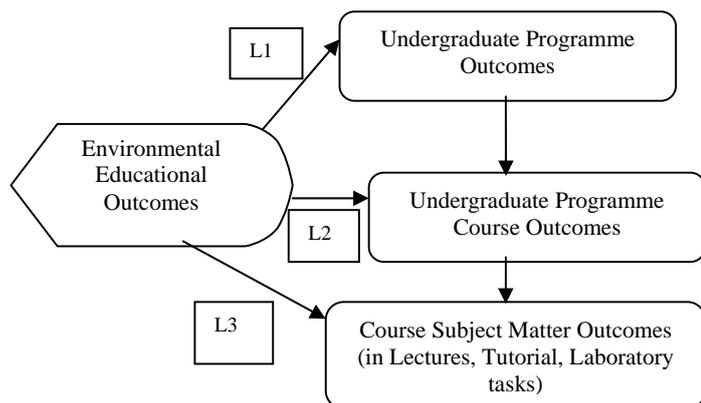International Journal of Educational and Pedagogical Sciences
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Fig. 1 Framework for the integration of environmental educational outcomes within undergraduate academic programmes

Fig. 1 denotes the framework that can be used by universities to integrate environmental educational outcomes within undergraduate academic programmes in their institutions. As seen in Fig. 1, L1, L2 and L3 refer to the three levels in which environmental educational outcomes can be infused within undergraduate academic programmes. L1 is in reference to the first layer of integration of outcomes, known as the Programme Outcomes. L2 refers to the second layer of integration, i.e. the Course Outcomes level. L3 denotes the last level of integration, i.e. at the subject matter level. As depicted in the figure, integration at this level can be done within lecture learning outcomes, tutorial learning outcomes as well as learning outcomes of laboratory tasks. The framework illustrated in this paper can serve as a generic integration framework. This is due to the fact that the framework has been built around important entities all academic programmes are based upon, which are the educational outcomes of an institution of higher learning. When implemented in the proper sequence, i.e. L1 to L2 to L3, the framework guarantees a systematic coherence and continuity of learning.

V. CONCLUSION

This paper discussed the manner in which a Malaysian university has created environmental awareness amongst its undergraduate engineering students through a structured environmental educational outcomes integration approach. The paper first discussed the important role higher education plays in advocating environmental consciousness in undergraduate academic programmes. The discussion was then centered upon an institution of higher learning in Malaysia which practices the inclusion of environmental educational goals within its undergraduate engineering programmes. Instances of environmental educational outcome integration at programme outcomes level and course outcomes level were then presented to provide a clearer understanding of the manner in which the integration of environmental outcomes were translated at both levels. Based on this university's structured approach to environmental consciousness, a generic framework that can be adopted or adapted by institutions of higher learning that wish to include

such outcomes within their academic programmes has been made known. The generic nature of this framework will prove to be useful for educational institutions, academicians and environmental organizations that wish to focus on developing environmental consciousness within their respective universities, classrooms and educational programmes.

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