RCEE & RHEd2010
Kuching,Sarawak
7 – 9 June 2010

Environmental Education for Sustainability: An Approach towards Sustainable Engineering in Industry

Woo Yoke Ling [a], **Ho Fu Haw** [b]
[a] Faculty of Technical Education, Universiti Tun Hussein Onn Malaysia
[b] Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia

Abstract

Global resources shrinkage has affected the earth towards a degradation trend. In the past decade, researches have shown that 70% of environment devastations came from world industrialization activities. It is clearly indicated that an urgent act should be taken to reduce and therefore minimize these environmental issues. Indeed, global change has urged all the nations and communities to take necessary and active parts in integrating moral and ethical values for the benefits of wider society. Therefore, sustainable development is the key element to be applied to ensure future growth. It is a concept of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but in the future as well. Efforts initially centred on the particular group of community, for instance manufacturers, but the public sensitivity of environmental education should also be emphasized in the engineering education. Since environmental education for sustainability was identified as one of the important tools for sustainable development, this paper discusses the recent trends and waves of correlation between environmental knowledge and engineering education in the path towards sustainable industry. The main concern issues are gathered from both engineering perspective as well as the environmental education field. From here, necessary actions are suggested to help the nation in creating a sustainable industry by integrating environmental aspects in engineering education.

Keywords: sustainable development; environmental education; engineering education, sustainable industry

1. Introduction

Industrialization has brought a great devastation to the global diversity and shrinkage of the earth's natural resources. Climate change was the direct impact that has rapidly happens around the global. In December 2009, the Copenhagen Climate Change Conference has been held in Denmark was a conference that emphasized on the climate change issues happened in the past decade [1], a global agreement among the committees have been made to cut greenhouse gas emissions to avoid the worst climate change projections. Following by the World Earth Day 2010, Preetum Shenoy [2] has stressed that the global is facing an alarming circumstances that need critical actions from the entire global stakeholder in the continued viability of Mother Earth, and take serious responsibility to deliver positive results against all actions we wanted to carry out. The main stream idea from this event is to build on the momentum of growing sense towards environmental and social consciousness. From here, it is clear that implementing a sustainable development in environmental element being a must especially to cope the promises of the agreements.

Sustainable development is a concept of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but in the future as well [3]. This concept founded on three dimensions (economic sustainability, social sustainability and the environmental sustainability) and it was brought to life and named by The World Commission on Environment and Development in 1987. Since its conception, the concept has become a major focus in the 1990s to the present time.

Therefore, Education for Sustainable Development (ESD) currently enjoys huge momentum. Internationally, there exists a strong commitment to integrate ESD in all levels of education, including the higher education sector. Its importance was recognized with the establishment of the United Nations Decade of Education for Sustainable Development (UNDESD) from year 2005 to 2014. UNESCO [4] defines the goal of UNDESD is to integrate the principles, values, and practices of sustainable development into all aspects of education and learning.

Malaysia is undergoing rapid industrialization towards achieving developed nation in 2020, yet this country has aimed at balancing economic and social development with environmental protection as highlighted in Malaysia's Vision 2020. The vision has enhanced challenges in engineering field, for

instance; climate change, sustainability, energy used, and internationalization. This trend is enquired engineers who are well prepared to provide innovative solutions in important areas. As a result, higher education today faces new challenges in preparing the engineers for the status of an industrialized nation by 2020 as education is a powerful factor in shaping future citizens who support environmental conservation [5].

Hence, engineering education in Malaysia should be geared towards achieving the aims of environmental sustainability. Cade and Druce [6] have emphasized it is the responsibility of all higher education academics, not only those teaching in the environmental fields, to ensure their students become competent in critically understanding and applying the principles of sustainable development. It is because these future workforces have a direct impact on the environment, they can play a crucial role in implementing practical solutions to current environmental problems [7]. Hence, it is essential that they are trained to understand environmental problems and make conscious of sustainable development, so that they can take concrete steps for its improvement.

2. Current trends and waves of sustainable industry

Sustainable industry system has been prioteried as a main requirement in most of the advanced countries since early of 20th centuries for their rapid growth [8]. But, there is a slow trend has been shown in the developing countries since revolution of industrialization. The initial idea of creating sustainable manufacturing system can be considered as main requirements or legislation rules especially to fulfill the ISO 14001 series [9]. However, changes of view should be made by the stakeholders or investors since the returns of sustainable industrial system are broadly worthwhile especially in the aspects of economy, social and environmental [10].

Nevertheless, there is a rapid growing trend of heavy industries in implementing sustainable industrial system especially in construction related industry. Although the implementation is continuous happens in other fields of engineering but the consciousness level is still remained at a lower range [11]. The urgency of conscious about the importance and the way of thinking are becoming vital because most of the stakeholder are lack in environmental as well as critical thinking in their management of organization [12].

In current trend of industrialization, researcher quotes that research should be focused on the emerging economies, especially in emphasizing the essential role of creativity and innovation in achieving saleable entrepreneurial solutions to the world's pressing sustainability challenges [13]. While environmental education being an effective solution to aid and ease the path towards creating a sustainable industrialization.

However, Subic [14] claimed end user being the central of creating sustainable thinking, and it means that manufacturers are indirectly influenced to produce their product in a sustainable way (process, industrial system) to fulfill the requirement of consumers (as shown in Figure 1). So, the change of industrialization is an overall change from every level of the stakeholder and not only focused on the manufacturer.

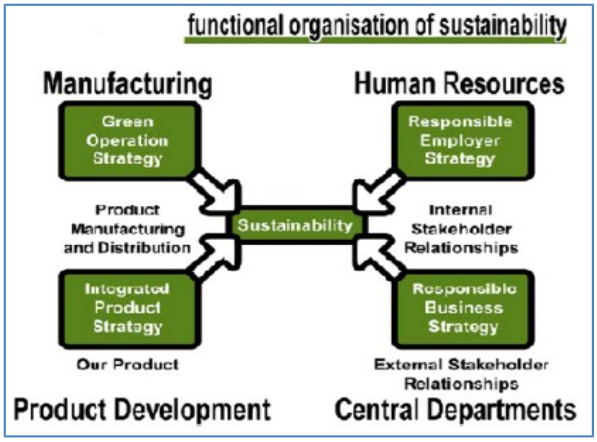

Fig. 1. Example of functional organization of sustainability in an industry setting

In short, acquiring environmental thinking or consciousness is a crucial effort that needed continuing implementation and participation of various parties. While environment education being a vital part in ensuring the success of implementing sustainable industry system, compromise from the involved parties is a must especially in applying the environmental knowledge in an effective way.

3. The needs of integration environmental aspects in engineering education

Nowadays, environmental degradation is a global concern. Rapid industrialization along with technological development is the key contributors of increased levels of pollution and waste. The role of future engineer in these technically development aspects is becoming more challenging due to the huge impacts of industry and engineering practices in our world. Ashford [15] urged engineering have to be focus more on the physical sciences or social science because the activities that drive the industrial state and implement scientific advance are generally rooted in engineering. A study made by the National Academy of Engineering have addressed there are several challenges that require effective solutions by engineering ingenuity and two challenges have been highlighted here are; firstly, concerns to the environment and climate change, secondly,

destruction and depletion of natural resources and non-renewable source of energy.

In order to solve these problems, we need to have engineers who able to understand the environmental problems and become conscious of sustainable development so that they may contribute to its establishment in a meaningful way. The engineer has an immediate and direct impact on the environment, they play a crucial role in implementing practical solutions to current environmental problems. Therefore, to make the industry system in a sustain way, they will need to acquire more advanced core knowledge as well as technical skills and soft skills to cope with the current demand of industry to protect the environment.

Education process cannot be denied as an efficient way to expose the student with the environmental concepts. It has been recognized that the best approach to reach out to the future engineers is through their educational institutions. Lauglo and Maclean [16]claimed education plays an essential role in promoting both economic and ecologic needs, and empowers people to contribute to environmentally sound sustainable development in the twenty first century through their occupations and other areas of their lives. For this reason, the development of engineering education is important for the creation of skills and knowledge needed in sustaining the industry. As stated by Abdul-Wahab *et al.* [7], engineering education has a significant effect on the environmental problems in industry, because with the workers attitudes and practical actions, it will influence the contribution of industry to the process of environmental sustainable development. To be able to do this effectively, workers are firstly need to gain knowledge and skills in environmental aspects.

Environmental education is identified as one of the important tools for sustainable development. It is an educational process about, for and through the environment to upgrade the living standards of people. Abdul-Wahab *et al.* [7] have outlined several rationales for exposing engineering students to environmental education and there are three rationales have been highlighted here:

i. Engineer plays a vital role in environmental protection, reducing the impact of new activities and correcting existing problems. Therefore, they should possess the scientific and technical knowledge to identify, design, build and operate systems that allow development while protecting the environment.
ii. Through the introduction of environmental issues alongside their training in engineering, engineers will develop the habit of considering the environment in all aspects of their work.
iii. Due to the experiential thought, one never comes to fully understand a problem with all its complexities until one fully immerses oneself into the problem. Therefore, engineers should be trained to consider environmental aspects in all their work.

It can be seen that the engineering graduates are the interface of nature, technology as well as industrial processes and having a key role to play in helping society resolve environmental and development issues. Therefore, it is crucial to have the engineering graduates with well prepared to deal with the environmental challenges in current industrial trend.

4. A review of barriers in engineering education towards environmental for sustainability

The need of inclusion environmental education into engineering studies in order to raise environmental awareness in the early stages of engineer has been discussed in the previous section. However, despite the obvious need of more environmental design education in engineering education, there are some barriers of change need to be overcome. Some of the major problems are:

i. Lack of awareness and appreciation of environmental issues among the academics and students

Lack of awareness and appreciation of environmental issues or low civic consciousness among the academics and students is one of the reasons for resistance to change in engineering education eventually contribute to environmental deterioration in the country. Dahle and Neumayer [17] summarized the factors they felt act as barriers to change and they have been stressed on the lack of interest and commitment towards environmental initiatives among staff and students. It is because they are unfamiliar with the environmental education and lack of knowledge in environmental issues.

Many of them are still unaware of environmental impacts of human activities produced by them although they may feel vaguely and most of them do not care unless directly affected. For this reason, they are unlikely to show efforts or demands for environmental protection and enhancement. It has the similarity of issue happening in most of the Small and Medium Enterprises (SMEs). SMEs are currently not aware of impinging legislation or the environmental impact created [18]. On the other hand, SMEs are quoted as contributing 70% of global environmental pollution [19] with the majority coming from manufacturing sectors.

ii. **The academics are lack of knowledge and experiences on integrating environmental aspects into engineering education.**

The other obstacle to adapt the environmental education in engineering education is the shortfall in human resources. Alabaster and Blair [20] and a coupled of observation groups [21] have argued one of the reasons that resist to change among the academics is they are lack of knowledge in how to combine information about the environment with the core knowledge of their course. Therefore, they seem to see the possibilities for changing current programmes as being too difficult. On the other hand, they may feel that the integration of environmental aspects are outside the boundaries of their discipline. Hence, they may not feel comfortable to work across discipline when the core knowledge has to be taught in the context of environment understanding.

Sterling & Thomas [22] claimed the only people who can achieve the development and delivery of education for sustainability are the academic themselves. This is because the development of environmental education is the fact that only academics devoted to promote and implement the environmental education in teaching and learning process [23]. As a matter of fact, these academics are not to be trained and they are not aware of how environmental aspects should be integrated into technical programmes. Thus, it will be difficult for academics who have not been trained to do all the work to develop a set of capabilities themselves, not least as it engages them in a role as learners as teachers.

It can be seen that in most countries, the responsible of imparting environmental education is passed on to the existing staff that may not be specifically trained for the purpose. Consequently, this will hamper the effective integration of environmental education in engineering education and the promoting of this concept into engineering studies is also unable to be done in the desired perspective.

This scenario is similar with what have happened in industry recently. Most of the manufacturers are less in exposure of integrating the environmental knowledge into the industry system, this has brought direct impacts for them to perform integration. Based on the recent research done by James Scott *et. al.* [24], the main barriers facing by most of the manufacturers is how to integrate and implement sustainable industrial system into their existing working environment.

iii. **Lack of focus on environmental issues in engineering curriculum**

Julie and Martha [25] indicated that integrating environmental education into curriculums is the most effective ways of increasing the effectiveness of environmental education. However, WWF-Malaysia [26] has pointed out one of the reasons for lack of implementation environmental education in Malaysian society is infusion of environmental education is not compulsory and as such depends entirely on the teachers and principals of institutions on how to deliver, support and design the environmental education programmes.

On the other hand, in the curriculum of engineering education there is an argument that it has been too focus on promotion of technical aspects and abandoned the environmental concern [5]. Engineering education is usually described in terms of a curriculum designed to present the set of topics engineers "need to know" and it has been led to the conclusion that an engineering education is just focus on the technical, technology and core knowledge of engineering. Although the course contents may be valuable but it seems engineering education has ignores the need for integration of environmental issues which many believe should be at the core of an engineering education.

Nevertheless, Sterling & Thomas [22] are concerned with how to begin movement in curriculum towards Education for Sustainability where there is currently none or very little. As the case in United Kingdom, for instance; current work by the Higher Education Academy ESD Project shows a growing willingness among academics to embrace sustainability, but real issues are about how to do so are given common constraints [27].

5. Recommendation

Development of a country especially when the main economy source is depends on country's industrialization has brought us into a new trend "How to Work in a Sustainable Way" or creating a sustainable industry system to enable all the nations beneficial from it.

Future engineers are needed to be trained to fulfill the sustainable characteristics and the capability to work in a versatile environment. Indeed, the path of preparing these engineers may be a great challenge especially to cope with current competitive environment. Therefore, environmental education has been recognized as an effective approach towards boosting the awareness and insight understanding of the needs of this knowledge especially in the engineering related fields.

There are some recommendations have been outlined here to solve the raised barriers in this paper:

i. **Enhance the awareness and appreciation of environmental issues among the academics and students**

To enhance the environmental awareness among the academics and students, it is crucial for them to

easy access to the related information. New information and communication technologies need to be incorporated in teaching and the development of a learning process that would be able to keep the academics and students abreast of latest legislation, issues, and environment friendly technology. Furthermore, they have to expose with the studies and researches related to environmental issues. Therefore, these studies should be accessibility and always available for them. In addition, it would be needed for the institution to team up with any local manufacturers who have the experience in improving resource productivity. With this, they may provide the academics and students with the understanding of issues in industry and eventually compromise between engineering and environmental needs.

ii. **Enhance the knowledge and experiences on integrating environmental aspects into engineering education among the academics**

Abdul-Wahab *et al.* [7] stressed engineering curriculum are already packed tight with courses, and therefore it might not be possible to introduce an extra module to address the environmental issues. Thus it may be possible to emphasize the environmental challenges that will confront workers through their career within each module. Furthermore, inter-disciplinary perspective indicates that development of curriculum of education for sustainability cannot be done by a central curriculum unit. It is because a "one-size" curriculum will not suit the needs of the different disciplines. Preferably the curriculum of education for sustainability will be specifically related to issues and needs of the specific discipline. Therefore, it is suggested a standard curriculum development model with enough flexibility to incorporate discipline needs should be developed for engineering programmes. This model can be acted as guidance, and which can be modified by the individual academics to suit their discipline area and their teaching needs. With this, academics are able to integrate this concept effectively in the process of curriculum development.

Teaching ability in environmental education should be linked to professional qualifications and opportunities also need to be provided to academics for environmental studies [28]. Therefore, it is essential that the institutions develop a training programme for the academics. Furthermore, it is suggested that teacher performance assessment should be included their commitment and competencies in the techniques consist of environmental elements.

iii. **Enhance the focus on environmental issues in engineering curriculum**

Engineering students must be trained to handle the various problems that might be occurred in the world of work with finding the sustainable solutions and implementation options for the short and long term purposes.

To accomplish this, the academics need to educate the engineering graduates not only in the technical skills which are essential to the practice in their profession; instead they should be trained to explore the various alternatives for environmental solutions. In other words, they should become environmentally conscious and view the environmental impacts on the decision making process and holistic manner. Therefore, engineering education should provide experiences of analytical thinking, problem solving, decision making and participation with the consideration of environmental, political, economic, social and ethical aspects. This will nurture the future engineers to be creative, critical and flexible in finding the various solutions in their work. Besides, it should also promote the changes in attitudes and behavior among the graduates that might help in solving the existing problems that related to the environment. Therefore, the idea of environmental for sustainability cannot remain as an isolated field of expertise; however it must form the mindset for everyone.

Furthermore, in order to achieve this aim, every engineering education need to formulate a more organized and well-planned curriculum to improve the contents of environmental aspects in the programmes. It is suggested every manufacturing and industry courses must include a substantial component of explains climate change and resource productivity issues as well as how the industrial system interacts with the social and environmental systems of the planet. Besides, all the courses to be taught to engineering students should be emphasized in their contribution to sustainability and course projects must include some environmental issues that enquired them to think of the solutions. By this, graduates are able to be trained become environmental conscious when they have immerses themselves in the problems.

6. Conclusion

In the context of sustaining the industry system, environmental education is being a key player in identifying elements to be met and acquired in fulfilling the needs in environmental consciousness especially in the aspect of moral and ethical values.

To ensure and remain a sustainable future, environmental sustainable education should continuously reinforce by institutions. It is hoped that this will lead to a better understanding of the environmental concepts adaptability among the engineering students and produce an effective programme that would be helpful in fostering environmental awareness among the graduates. With

that, we can produce the future engineers who have the capability to protect the environment while compete with the rapidly change globalizing world and in the same time bringing our community and nation to a more sustainable development. Even though technology is perceived as a creator of environmental problems, in fact, only science and technology could lead to sustainable development and improve the quality of life with compromise of environmental concern from various parties.

In short, the new approach of engineering education system is a must to prepare graduate in multi-disciplinary thinking. Engineering education has a responsibility to increase the awareness, knowledge, technologies and tools to create a more environmentally sustainable future. It is undeniable integrating environmental concerns into the engineering education is a difficult process and there are some barriers that need to be overcome but the awareness on the importance of the environment is highly needed. Therefore, engineering education must have a long term view of planning far into the future and environmental impacts.

References

1. Copenhagen Conference 2009. Retrieved April 20, 2010, from http://www.greenlivingpedia.org/Copenhagen_Climate_Change_Conference_2009
2. World Earth Day 2010 (Speech from sustainability team Earthday 2010: Preetum Shenoy). Retrieved April 20, 2010, from http://www.sustainability.com/researchandadvocacy/columns_article.asp?id=1724
3. WCED (1987). ‘‘Our Common Future’’ World Commission on Environment and Development. Oxford: Oxford University Press.
4. UNESCO (2005). United Nations Decade of Education for Sustainable Development (2005-2014)-International Implementation Scheme. Paris: UNESCO.
5. Yusoff, S. (2003). The Need for Emphasis on Environmental Education for National Development in Malaysia. Masalah Pendidikan. 26, 75-82.
6. Cade, A. & Druce, D. (2007). Employable Graduates for Responsible Employers – Research on the Links between Sustainability and Employability in the Graduate Job Market in Relation to Higher Education Teaching and Learning. Work Draft of Final Report for Higher Education Academy ESD Group, Student Force for Sustainability.
7. Abdul-Wahab, S. A., Abdulraheem, M. Y. & Melanie, H. (2003). The Need for Inclusion of Environment Education in Undergraduate Engineering Curricula. International Journal of Sustainability. 4(2), 126-137.
8. Hezri, A.A. (2004). Sustainability Indicator System and Policy Processes in Malaysia: A Framework for Utilisation and Learning. Journal of Environmental Management. 73, 357–371.
9. Luken,R. & Rompaey, F. V. (2008). Drivers For and Barriers to Environmentally Sound Technology Adoption by Manufacturing Plants in Nine Developing Countries. Journal of Cleaner Production. 16S1, S67-S77.
10. Abdul Rashid, S. H., Evans, S. & Longhurst, P. (2009). A Comparison of Four Sustainable Manufacturing Strategies. International Journal of Sustainable Engineering. 1(3), 214-229.
11. Kumar, V. *et. al.* (2005). Infusing Sustainability Principles into Manufacturing/Mechanical Engineering Curricula. Journal of Manufacturing Systems. 24(3).
12. Tsai, W. H. & Chou , W. C. (2009). Selecting Management Systems for Sustainable Development in SMEs: A novel hybrid model based on DEMATEL, ANP, and ZOGP, Expert Systems with Applications. 36, 1444–1458.
13. Sustainability Tomorrow’s Value: Trends and Waves. Retrieved April 20, 2010, from http://www.sustainability.com/insight/trends-and-waves.asp
14. Subic, A. (2009). Transdisciplinary dimensions of sustainable design practice. International Journal of Sustainable Design. 1(2), 127 – 129.
15. Ashford, N. A. (2004). Major Challenges to Engineering Education for Sustainable Development: What has to change to make it creative, effective, and acceptable to the established disciplines? International Journal of Sustainability in Higher Education. 5(3), 239-250.
16. Lauglo, J. & Maclean, R. (2005). Vocationalisation of secondary education revisited. Netherlands: Springer.
17. Dahle, M. & Neumayer, E. (2001). Overcoming Barriers to Campus Greening: A Survey among Higher Educational Institutions in London, UK. International Journal of Sustainability in Higher Education. 2(2), 139-160.
18. Burke, S. & Gaughran, W.F. (2007). Developing a Framework for Sustainability Management in Engineering SMEs, Robotics and Computer-Integrated Manufacturing. 23, 696–703.
19. Hillary R. (2004). Environmental Management Systems and The Smaller Enterprise. Journal of Cleaner Production. 12 (6), 561–569.
20. Alabaster, T. & Blair, D. (1996). Greening the University. Education for Sustainability. Earthscan, 86-104.
21. Thomas, I. (2004). Sustainability in Tertiary Curricula: What is Stopping It Happening? International Journal of Sustainability in Higher Education. 5(1), 33-47.

22. Sterling, S. & Thomas, I. (2006). Education for Sustainability: The Role of Capabilities in Guiding University Curricular. International Journal Innovation and Sustainable Development. 1(4), 349-369.
23. Rohweder, L. (2004). Integrating environmental education into business schools' educational plans in Finland. GeoJournal. 60, 175–181. Kluwer Academic Publishers.
24. Baldwin, J. S., Allen, P. M., Winder, B. & Ridgway, K., (2005). Modelling Manufacturing Evolution: Thoughts on Sustainable Industrial Development. Journal of Cleaner Production. 13, 887-902.
25. Julie, E. & Martha, M. (2004). The Effects of Environment-based Education on Students' Critical Thinking Skills and Disposition Toward Critical Thinking. Reprinted from Environmental Education Research. 10 (4), 507-522.
26. WWF- Malaysia, (2006). A Concept Paper on "Revolutionizing Environmental Education in the National Education System: From Concepts to Practices". An unpublished Conservation Education Proposal.
27. Dawe, G., Jucker, R. & Martin, S. (2005). Sustainable Development in Higher Education: Current Practice and Future Development: Executive Summary, A Report for the Higher Education Academy. Retrieved December 18, 2009,from http://www.heacademy.ac.uk/4074.htm
28. Integrating Environment Education in Technical and Vocational Education in Asia, Report of the Workshop, 3rd to 5th September 2003, Chandigarh India. Retrieved April 15, 2010, from http://portal.unesco.org/education/en/file_download.php/f9dff494ba9889e5b23e5bdc3e854c82Workshop+Integrated+Report.pdf