AC 2012-4766: ENVIRONMENTAL SUSTAINABILITY EDUCATION: TOOL TO IMPROVE SUSTAINABLE ENTREPRENEURSHIP AND BETTER POLICY?

Mr. Ganapathy Subramanian Natarajan, Texas Tech University

Gana Natarajan is a Ph.D student in Systems and Engineering Management at Texas Tech University, Lubbock, TX. He has a Master's in Engineering Management from University of Minnesota Duluth and a bachelor of engineering in Mechanical Engineering from Anna University, India. His research interests are sustainable practices in small and medium-sized enterprises and sustainability education.

Mr. Chinweike I Eseonu, Texas Tech University

Chinweike Eseonu is a doctoral student in Systems and Engineering Management at Texas Tech University. Mr. Eseonu's area of research focus is public policy and technical entrepreneurship, with focus on the effect of networks and technical professionals on the policy process. Mr. Eseonu is a graduate of the Department of Mechanical Engineering at the University of Ottawa and received his Masters in Engineering Management at the University of Minnesota.

Dr. David A. Wyrick PE, PEM, Texas Tech University

David A. Wyrick is Professor and Bryan Pearce Bagley Regents Chair of Engineering at Texas Tech University. He has accepted the position of Dean of the School of Science and Engineering at Al Akhawayn University in Ifrane, Morocco. His interests include effective management of technology, small and medium enterprises (SMEs), sustainability and technical policy, engineering education, and learning abroad for engineers. He has taught capstone design for mechanical engineering, industrial engineering, and engineering management programs, primarily in cooperation with external clients. At Texas Tech University, he developed a faculty-led course in International Engineering that has been offered in Nantes, France, and Lule, Sweden.

Previous to the 2007, he was at the University of Minnesota Duluth, including 9 years as head of the Department of Mechanical and Industrial Engineering. He has also been a visiting professor at Lule University of Technology in Sweden. He has over 6 years of experience in the oil and gas and computer industries, and has worked with small companies on process improvement projects. Beginning in the summer of 2012, Dr. Wyrick will assume the position of Dean of the School of Science and Engineering at Al Akhawayn University in Ifrane, Morocco. He received his Ph.D. from the University of Missouri-Rolla in Engineering Management, M.S.E.M. from the University of Alaska, Anchorage and B.S. and M.S. in Mechanical Engineering from the University of Wyoming.

Dr. Wyrick is a licensed professional engineer and is a certified Professional Engineering Manager. He has been active with ASME since joining as a student in 1977, serving as Secretary and President of the Alaska Section, on the board of the Management Division, and founding faculty advisor of the student section at the University of Minnesota Duluth. He is currently President of the American Society for Engineering Management. Dr. Wyrick is a member of the American Society for Engineering Education, Institute of Industrial Engineers, US Association for Small Business and Entrepreneurship, the International Association of Engineers, and Tau Beta Pi.

Environmental Sustainability Education: Tool to Improve Sustainable Entrepreneurship and Better Policy?

Small and Medium-sized Enterprises (SMEs) are defined to employ fewer than 250 employees in Europe and fewer than 500 in the United States (Hussey & Eagan, 2007)[1]. Small and Medium-sized Enterprises (SMEs) contribute between 80% and 90% of all industries (Moore & Manring, 2009;[2] Pimenova & van der Vorst (2004);[3] Shearlock, Hooper, & Millington (2000);[4] Walker & Preuss, 2008[5]) in the world. The pollution caused by SMEs is also high due these high numbers. Implementing environmentally sustainable practices is of utmost importance in the current situation. One of the major factors affecting companies following such sustainable practices is the culture of the company (Natarajan & Wyrick, 2011)[6]. The owner (or group of owners) affects the culture heavily, given the small size of SMEs. Research has shown that owners with prior education about environmentally sustainable practices are more likely to be proactive in implementing such practices in their companies (Ben-zvi-Assaraf & Ayal, 2010;[7] de Eyto, Mc Mahon, Hadfield, & Hutchings, 2008;[8] Lukman, Kranjc, & Glavic, 2009[9]). However, programs aimed at environmentally sustainable entrepreneurship are scarce in the United States. Some universities in the European Union have successfully integrated sustainable entrepreneurship courses. The follow-up studies have shown that students who were part of the program were more proactive in pollution control, both as owners and employees of SMEs.

Policy makers across the United States are in search of sustainable policy practices that ensure job creation and revenue streams, while satisfying sustainability goals. Literature shows that the rate of technological progress far outpaces the rate of related policy implementation (Eseonu & Wyrick, 2011[10]). It also shows that universities remain one of the most effective means of knowledge management to combat this lag between policy and technology progress. This paper discusses the European cases of sustainable entrepreneurship curricula at universities and the resulting effect on policy and practice. The discussion will inform recommendations for incorporating sustainability and entrepreneurship into engineering curricula.

Lessons Learned from European Cases

Sustainability is becoming an integral part of engineering education (Ben-zvi-Assaraf & Ayal, 2010[7]). In Europe it is integrated into most engineering programs. The study by Ben-Avi-Assaraf and Ayal (2010)[7] with a university in Israel indicated that the students who studied the "Environmental Management Systems in Industry" course had increased environmental awareness. De Eyto et al., (2008)[8] and Lukman et al., (2009)[9] have discussed the role of universities, students, and SME professionals in developing strategies that foster sustainable practices in the UK and Slovenia, respectively. The research by de Eyto et al., (2008)[8] discusses how sustainable literacy can be a potential addition to the skill set of an undergraduate. They suggested educational models and network collaboration based on studies conducted with Irish

undergraduate students from the Institute of Technology, Carlow, and the University of Limerick. The students and the universities collaborated with SMEs in offering services wherein the students started at the conception stage and worked up to the final deliverables. As a precursor to this live project experience, students were involved in multidisciplinary learning in order to foster the environmental thinking and mindset. The authors observed that the sustainability literacy and the experience gained from the live projects helped the students, from a follow up study, be initiators of sustainable practices elsewhere. The study by Lukman et al., (2009)[9] establishes the position of the University of Maribor, Slovenia, in improving collaboration among various entities in order to improve sustainability initiatives at a regional level. They suggested that, "academic research has an important role to play but only if interdisciplinary and multidisciplinary thinking and learning are brought into effect…," (p. 1143). According to them, an open systems model where there is participation from universities, local community, local governments, NGOs, and other stakeholders is the ideal setup for better implementation of sustainable practices in SMEs. Collaborative learning was suggested as a major tool in bringing about the change, based on the case of local SMEs in Maribor. The results showed collaboration among the University of Maribor, Municipality of Maribor, NGOs, and other local agencies.

The different cases and other research articles point towards an interdisciplinary engineering education to foster sustainable thinking. The cases also indicate that integrating sustainable education as part of the curriculum improves the environmental awareness among the students.

Challenges to Implementation in the United States

Eseonu and Wyrick (2011)[10] introduce an application of physical heat transfer to the process of policy transfer. They explain that similarities and differences between countries determine the rate and success of policy transfer. Sustainability is a less culturally sensitive subject in Europe than is the case in the United States. This difference is reflected in business and educational practices, as discussed above. Cultural adversity also affects institutional support for initiatives perceived as sustainable or "green."

Dennis (2011a)[11,] (2011b) [12] suggests that institutions and culture are two major levers used to influence SME growth and entrepreneurship culture. He suggests that a lagging culture can be led by institutions, such as universities (Ylinenpaa, 1998;[13] Siegel, 2007[14]). Engineering education at universities provides one such avenue for institutional leadership in light of global competition for (1) employment, (2) sustainable projects, (3) international students, and (4) natural resources.

The Education – Entrepreneurship – Sustainability - Policy Connection

Small and Medium-sized Enterprises (SMEs) face different barriers to implement sustainable practices. Some of the major barriers were consolidated by Natarajan & Wyrick (2011)[6]. The major barriers were finance, lack of expertise, lack of information, and company culture.

Similarly there were factors that motivated firms towards better environmental practices. The major motivators were legislation, owner(s) perspective, customer demands, and internal drive.

SMEs struggle with understanding environmental sustainability due to the lack of people with sustainability education in their organization. In addition an owner or a group of owners with a positive and proactive environmental outlook helps the SMEs in implementing environmentally proactive practices.

SMEs usually have one or a small group of owners who are involved in most of the decision making. A certificate course at Texas Tech University offers a technology entrepreneurship program. The program brings together engineers and business school students to foster interdisciplinary education. The enrollment in the program and the success of the course suggests that engineering and business graduates are interested in being entrepreneurs in future. This trend suggests that small businesses will continually be started causing increasing environmental impact.

In this light, it becomes important that entrepreneurs who are product of our educational system be informed on environmentally sustainable practices. Irrespective of the size of the company they are involved with, they can champion the change towards better environmental practices. Lack of expertise can be removed and the internal drive can be increased in order to push towards better environmental practices. Hence it is important that environmental education is part of every engineering curriculum and also part of any business curriculum.

Legislation is one of the motivators towards better environmental practices in SMEs. Culture was identified as a factor that enables policy diffusion by Eseonu and Wyrick (2011)[10]. Entrepreneurs with a proactive outlook towards environmental practices can provide a positive culture. A positive culture results in faster policy diffusion as the positive culture acts like a highly conductive material promoting heat transfer. Literature shows that networking and making SMEs work together improves their environmental sustainability. A culture that is highly conducive for policy diffusion is a desirable state for legislators. SMEs that are accepting of legislation and proactive with environmental implementation will contribute to constantly evolving better practices.

Recommendations for Implementation

Integrating environmental education into engineering education will take time and cannot be achieved overnight. The following are some initial steps that can help in the ultimate integration. Senior design projects are in most cases in collaboration with an outside organization. The curriculum can be altered such that senior design projects are geared towards applying sustainability to students' area of study. This will result in developing integrated and interdisciplinary approach towards sustainability. Students applying the concepts of sustainability in real world will improve their outlook when they become entrepreneurs. Courses on Environmental Management Systems (EMS) will help improve student expertise on

sustainable management. EMS such as the ISO 14001 can be applied to a variety of industries as it provides general guidelines and metrics to implement and measure environmentally sustainable practices. Courses and projects relating to sustainability can be a platform which can be used to develop a curriculum geared towards sustainable education.

Conclusion

The model discussed in this paper is a theoretical model that does not take into account other barriers in integrating environmental education with engineering education. However this paper provides an important connection between engineering education, sustainable education, entrepreneurship, and policy making that will affect not only the environment but also the economy and the society. Better concentration on sustainable development will result in the earth's ability to provide raw materials and receive back wastes. Sustainable development therefore plays an important role in providing a space for our existence. Sustainable development can be achieved effectively and efficiently through sustainable education. Sustainable awareness among our current and future entrepreneurs will effect better policy decisions contributing to the growth of our society.

Acknowledgments

We acknowledge the financial support provided by Dr. David Wyrick, the Bryan Pearce Bagley Chair endowment from the Whitacre College of Engineering at Texas Tech University. Dr. Wyrick also provided support with writing and editing this paper.

Bibliography

1. Hussey, D. M., & Eagan, P. D. (2007). Using Structral Equation Modeling to Test Environmental Performancs in Small and Medium sized Manufacturers: Can SEM help SMEs? Journal of Cleaner Production , 15 (4), 303-312.
2. Moore, S. L., & Manring, S. L. (2009). Strategy Development in Small and Medium sized Enterprises for Sustainability and Increased Value Creation. Journal of Cleaner Production , 17 (2), 276-282.
3. Pimenova, P., & van der Vorst, R. (2004). The role of support programmes and policies in improving SMEs environmental performance in developed and transition economies. Journal of Cleaner Production , 12 (6), 549-559.
4. Shearlock, C., Hooper, P., & Millington, S. (2000). Environmental improvement in Small and Medium-sized Enterprises: a role for the business-support network. Greener Management International (30), 50-60.
5. Walker, H., & Preuss, L. (2008). Fostering sustainability through sourcing from small businesses: public sector perspectives. Journal of Cleaner Production , 16 (15), 1600-1609.
6. Natarajan, G.S., & Wyrick, D.A. (2011 a). Framework for implementing Sustainable Practices in the United States. Proceedings of the World Congress on Engineering 2011, I, 750-754.
7. Ben-Zvi-Assaraf, O. & Ayal, N. (2010). Harnessing the Environmental Professional Expertise of Engineering Students – The Course: "Environmental Management Systems in the Industry. *J. Sci Educ Technol, 19,* 532-545.
8. de Eyto, A., Mc Mahon, M., Hadfield, M., & Hutchings, M. (2008). Strategies for developing sustainable design practice for students and SME professionals. European Journal on Engineering Education , 33 (3), 331-342.

9. Lukman, R., Krajnc, D, & Glavic,P. (20090. Fostering Collaboration between Universities regarding Regional Sustainability Initiatives – the University of Maribor. *Journal of Cleaner Prodcution, 17,* 1143-1153.
10. Eseonu, C. & Wyrick, D. (2011). Government Policy and SME Viability: The Heat Transfer Model for Diffusion of Government Policy for Technical SMEs. *Proceedings of the World Congress on Engineering 2011, I,* 702-706.
11. Dennis Jr, W. J. (2011a) Entrepreneurship, Small Business and Public Policy Levers. *Journal of Small Business Management, 49,* 149-162.
12. Dennis Jr, W. J. (2011b) Entrepreneurship, Small Business and Public Policy Levers. *Journal of Small Business Management, 49,* 92-106.
13. Ylinenpää, H. (1998). "Northern Light" or "Out in the Cold" - A comparison of two Nordic regions. Conference on *SMEs and Districts: Hybrid Governance Forms, Knowledge Creation & Technology Transfer', LIUC, Castellanza.*
14. Siegel, D. S. (2007). Quantitative and Qualitative Studies of University Technology Transfer: Synthesis and Policy Recommendations. *Handbook of Research on Entrepreneurship Policy, eds. D. B. Audretsch, I. Grilo & A. R. Thurik,* 186-199.