

# Role of Environmental Education in Engineering Curriculum

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**Abstract:** *Our mother earth is the most precious gift of the Universe. It is the sustenance of “nature” that is a key to the development of the future of mankind. The environmental awareness is expected to be a part of the characters of young people. Most environmental education researchers suggest developing an environmentally literate society as the best strategy to overcome human exploitation of the world resources. Following the Supreme Court directives environmental education has been included in the curriculum of all universities and affiliated colleges in India. India being a developing country, environmental education is not attaining much importance even though it is included in curriculum. There is a significant gap between environmental education and other engineering core subjects. Engineering students express their opinion that the environmental education is useful to save environment and conservation of resources, but students are in misconception that environmental education is not relevant to their core subjects and not useful for their engineering carrier. It is recognized that engineers of the future must be trained to make decisions in such a way that our environment is preserved, social justice is promoted, and the needs of all people are provided through global economy. The environment is closely related to sustainable development. Many papers find that education is positively correlated with pro-environmental behavior in a range of contexts. For example, multiple studies find that individuals with higher education are more likely to recycle. The main idea of this article is to eliminate misconceptions about environmental education, significance of environmental education in engineering education for sustainable development, to bring correlation between education and environment.*

**Keywords:** *Environmental education Sustainable development, Technology, Engineering education, Pro-environmental behavior.*

## I. INTRODUCTION

Our mother earth is the most precious gift of the Universe. It is the sustenance of “nature” that is a key to the development of the future of mankind. The environmental awareness is expected to be a part of the characters of young people. Environmental issues have been a trending topic nowadays. UN Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in 1992. Agenda 21 of this conference identifies environmental education as one of the catalyst for sustainable development. In chapter 36, it states “Education is critical for promoting sustainable

development and improving the capacity of people to address environment and development issues” (UN, 1992). Environmental education has dual purposes. First is to increase the students’ environmental awareness for preventing environmental damaging behaviours and natural disasters. Second is to develop their understanding that environmental preservation and improvement of environmental quality will lead to the comfortable living, which eventually improves the quality of life in the society as well. The environmental education here consists of increasing the environmental awareness in an individual’s everyday life, and as a group, in business and professional practices. Most environmental education researchers suggest developing an environmentally literate society as the best strategy to overcome human exploitation of the world resources (UNESCO, 1997; Roth, 1996; Wilke, 1995). The term environmental literacy was first defined by Charles E. Roth in 1968 (as cited in Roth,1992). Environment literacy is essentially the capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems. The degradation of our environment is linked with the development process and the ignorance of people about retaining the ecological balance. Indeed, no citizen of the earth can afford to remain aloof from the issues related to the environment. It is, therefore essential that the study of the environment becomes an integral part of the education process. If we want to protect and manage our planet earth on sustainable basis, we have no other option but to make all persons environmentally educated.

Introduction about the environment in syllabus can help to create positive attitudes and actions towards caring for the environment and having strong sense of responsibility to the world (Palmer and Neal, 1994). Most universities around the world have developed strategies to integrate the concept of environment and sustainable development into education and research and the overall management of care that is appropriate to the needs of the environment. Learning about the environment not only restricted to environmental courses, but it is important for the engineering students also because according to the organization for American Engineering Education, ASEE (ASEE, 1999), engineering students should learn about

environment and sustainable development and sustainability in the general education component of the curriculum as they are preparing for the major design experience. The United Nations (UNESCO) launched the "Decade of Education for Sustainable Development, (DESD)" (2005-2014), among other initiatives and expressed the need for revising the holistic educational system starting at the early stages of schooling (kindergarten) up through the university level, with an emphasis on environmental sustainability or caring (Juarez-Najera et al., 2010).

## II. ENVIRONMENTAL EDUCATION AS A MANDATORY SUBJECT

Following the Supreme Court directives (Supreme Court of India, 1999) environmental education has been included in the curriculum of all universities and affiliated colleges in India. This directive was in fact, in response to a Public Interest Litigation (PIL) filed by M.C.Mehata Vs Union of India (1988). The prime objective of environmental education is to make everyone environment literate. Due to this reason environmental Studies has been included in the curriculum of engineering education. Environmental studies deals with every issue that affects a living organism (Erach Bharucha, 2005). It is essentially a multidisciplinary approach that brings an appreciation of our natural world and human impact on its integrity. It is an applied science, as it seeks practical answers to the increasingly important question of how to make human civilization, sustainable on the Earth's finite resources. Its components include biology, geology, chemistry, physics, engineering, sociology, health, anthropology, economics, statistics, computers and philosophy.

Being a faculty of Environmental Science in engineering college I observed a significant gap between environmental education and other engineering core subjects. Engineering students express their opinion that the environmental education is useful to save environment and conservation of resources, but students are in misconception that environmental education is not relevant to their core subjects and not useful for their engineering carrier. The basic needs of a human being are clean air, clean water, healthy food and other resources and these resources are available from nature to lead quality life. When good health and quality life are achieved, man can get success in his profession. However, India being a developing country, environmental education is not attaining much importance even though it is included in curriculum. This subject has been neglected. People think environmental considerations are hurdles for industrial development and financial growth. The main idea of this article is to eliminate misconceptions about environmental education, significance of environmental education in engineering education for sustainable development, to bring a correlation between education and pro-

environmental behaviour and to implement the environmental education more effectively in engineering education.

## III. ENGINEERING EDUCATION FOR SUSTAINABLE DEVELOPMENT

It is recognized that engineers of the future must be trained to make decisions in such a way that our environment is preserved, social justice is promoted, and the needs of all people are provided through global economy. The environment is closely related to Sustainable Development. Sustainable development has been defined in many forms (Coomer, 1979; Redclift, 1987; Tolba, 1987; WCED, 1987; Elliot, 2009; Jansen, 2003; Mog, 2004; Omer, 2008; Elliot, 1996; Goosen, 2012; Zaccai, 2012). Sustainable development is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". This definition was given in Brundtland commission report, "our common future", by the Norwegian Prime Minister, G.H.Brundtland, who was also the director of world health organisation (WHO). Literally, sustainability implies a continuous and a renewable ability to perform something. Sustainable development is therefore a type of development that is characterized by self perpetuating itself, it has an inherent generator or a dynamo that keeps it recharged and continuously keeps it 'going'. Being a good engineer is dependent on understanding and having a good grip on technical courses, especially mathematics and other sciences. In addition, an engineer needs to be able to appreciate society's needs, priorities society's problems, and, optimally and inter-temporally propose solutions, given the resources. Therefore, a more holistic engineering program is required; a program that is comprised of a good mix of engineering, scientific, technological knowledge, plus managerial, innovation, economic, communication, and more importantly ethical and moral knowledge and skills. It is obvious that educating young engineers on the basic ingredients of Sustainable development and sustainable living should be a key prerequisite in any engineering program. Three approaches are envisaged in this context:

- Stand-alone courses that provide historical evolution of sustainability concept and justification for Sustainable Development.
- Embed Sustainable development concepts in specialized engineering courses.
- Case studies, practical real-life examples, EIA, that are relevant to Sustainable Development.
- Sustainable development specialized seminars where professional and subject-related speakers from industry are invited.

The current engineering curriculum does not effectively incorporate Sustainable development concepts and its significance to society. It is thus important to expose, initiate awareness, and educate engineering students of the basics and fundamental issues in sustainability of mankind and its development. Topics that might be relevant in this context include industrial and economic development, environmental impacts, globalization, population growth and its general impact on resource use, availability, and environment, the social-cultural-political-ethical-and moral impacts of development, global crises and problems that confront mankind and the wider environment, and their relevant impacts on society and future generations. These are the contemporary issues that confront us and our environment.

The 2002 and 2004 International Conferences on Engineering Education in Sustainable development (a predominantly European event) emphasised that Engineering education, especially higher education for the training of decision-makers, researchers and teachers, should be oriented towards sustainable development and should foster environmentally aware attitudes, skills and behaviour patterns, as well as a sense of ethical responsibility. The 2004 conference declaration reaffirmed that, "Engineering has responded to the needs of society and without a doubt, today's society requires a new kind of engineers." It also stated, "Universities must redirect the teaching-learning process in order to become real change agents who are capable of making significant contributions by creating a new model for society. Responding to change is a fundamental part of a university's role in society. There is evidence that sustainable development has already been incorporated in engineering education in a number of institutions around the world. Both the 2007 Australasian Association for Engineering Education conference in Melbourne (Aae, 2007) and the 2007 International Conference in engineering sustainability in Perth feature engineering education for sustainable development as topics for deliberation. Several universities in the world have taken the lead in implementing environment and sustainable development in their engineering teachings. Universidad Auto'noma Metropolitana (UAM) is one of the public universities in Mexico prioritized environment and sustainable development in their research and teaching activities since 2005, starting with the Division of Basic Sciences and Engineering. According to Juarez-Najera et al., (2006), in developing the new education curriculum for environment and sustainable development at the UAM, the priority is to nurture and improve the sensitivity towards environment in the academic and professional cultures. We see it as important and necessary to reform education (re-education) and the program (re-programming). Another renowned university, Delft University of Technology in the Netherlands restructured its vision of "Towards a new commitment" to give priority

to the importance of sustainable development in education. According to Kamp (Kamp, 2006), in making changes to the education system towards sustainable development, new approaches are introduced in the course "Technology in Sustainable Development" for all Delft University of Technology students. This allow students not only to gain basic knowledge related to environment and sustainable development, but also able to connect the obtained knowledge to their field of study.

Engineering curriculum needs to incorporate contemporary issues in lifestyle such as consumerism, and life-cycle concept in its program. A product's footprint is dependent on many stages in its lifecycle: from inception stage-pilot scale-production-use-and, finally disposal. A product may be (or thought of) as green, but it might have adverse environmental (or other) impact at one stage of its lifecycle. An important addition to engineering curriculum is a course devoted to "Energy: sources, availability, use, efficiency, conservation, and environmental impacts". This addition is absolutely necessary for any engineering discipline. Our civilization, our development, and our well-being are all dependent on energy. Greenhouse gases and their impacts on sustainability of the planet are thought to be caused by use of fossil fuel as energy source.

Engineers are problem solvers. They are required and expected to make decisions that will affect their organization, themselves, and their society in terms of their well being, economically or otherwise. They are required to act professionally, ethically, and maintain social responsibility in their profession and in their decisions. Engineering projects such as airport construction, petroleum and natural gas, mining, chemical and petrochemical plants, and waste facilities all have apparent benefits and costs to society. Communities that live in close proximity to these projects may likely be affected (positively or negatively) by the proposed engineering projects. During recent decades many universities all over the world have signed declaration agree to implement sustainability through environmental curricula and research. The knowledge and capabilities required to manage corporate sustainability have become a significant component of several university graduate and postgraduate studies (Lozano, 2010; Waas et al., 2010). For a detailed literature review of the curricula in universities, including sustainability in professional practices, see e.g. (Hesselbarth and schaltegger, 2014).

In 500 BC, Chinese Tao patriarch Kuan Tzu is attributed with the following quote, "If you plan for one year, plant rice, if you plan for 10 years, plant trees and if you plan for 100 years, educate people". 20 years on from the publication of 'Our Common Future' (Bruntland, 1987) and 15 years since the first World Summit on Sustainable development (United Nations, 1992) there has been a concerning lack of progress on embedding sustainability

within higher education engineering education. In 1994, an international workshop of educators from the Asia Pacific region was convened in New Zealand to examine 'Fundamentals of Environmental Education in Engineering Education'. One of the conclusions of the workshop was that all engineers needed to be environmentally educated so they understood the issues involved in sustainable development and cleaner production. Shahrom md zain et al. (2015) reported that Engineering students were seen to have high level of environmental awareness either through their teaching and learning processes or information from the readily available sources, most commonly internet. Design projects are the most identified courses which expose them to the environmental and sustainable development elements. Most students across the engineering disciplines show concern and take seriously to conserve the environment. Emphasizing on environment and sustainable development and conservation towards environment in engineering education can increase student's confidence and their marketability once graduate. The teaching and learning approach must be improved so it is up to date and can increase students understanding on environment and sustainable development. Existing courses should be given extra attention so it follows the Accreditations Engineering Committee requirements. The engineering ethics and technology development is the potential course that can emphasis more on environment and sustainable development because it is a compulsory course for all departments and engineering ethics need a deep understanding about an engineer responsibility, not only towards mankind but also the environment.

#### IV. EDUCATION INCREASE PRO-ENVIRONMENTAL BEHAVIOUR

Many papers find that education is positively correlated with pro-environmental behaviour in a range of contexts. For example, multiple studies find that individuals with higher education are more likely to recycle (Callan and Thomas, 2006; Duggal et al., 1991; Ferrara and Missios, 2005; Reschovsky and Stone, 1994; Smith, 1995). Other research finds that education is correlated with food choices that affect the environment. For example, (Blend and Van Ravenswaay, 1999) find that higher levels of education increase the probability that a consumer would purchase eco-labelled apples. Several others find that education is associated with a higher probability of purchasing organics (Bellows et al., 2008; Monier et al., 2009; Zepeda and Li, 2007). Some studies have found that higher education levels are correlated with water saving behaviours (Berk et al., 1993; Gilg and Barr, 2006). Similarly, there is prior evidence that higher education levels are associated with energy saving behaviour (Mundaca et al., 2010; Poortinga et al., 2004). Furthermore, there is evidence that education is associated with more pro-environmental attitudes. For example, (Rowlands et al., 2003) find evidence that more educated

individuals are willing to contribute more for green electricity. (De Silva and Pownall., 2014) find that college educated individuals are more likely to sacrifice financial well-being to improve environmental quality and Xiao et al.(2013) find that more highly educated Chinese citizens report higher levels of environmental concern. Rosario Fernandez-Manzanal et al., (2015) reported relationship between pro-environmental action and environmental education. He reported that Graduates working in companies with ongoing environmental projects participated actively and felt that they had received an appropriate university environmental education. He proposed that firms and universities establish organisational structures to promote effective sustainability and pro-environmental actions.

#### V. VALUE –ORIENTED ENVIRONMENTAL EDUCATION

"The environmental crisis is an outward manifestation of the crisis of mind and spirit ". It all depends on how do we think and act. It is important to restructure and re-develop the way an engineer thinks, decides, and deals with members of his society. Ethics and moral values need to be reminded and re-instilled in an engineer's mind. Transparency and commitment to truth should be key qualities that form the personality of an engineer. Courses, seminars, debates and actual scenario-based case studies on ethics and moral behaviour are proposed. Exposure to, and education in actual case studies are necessary in order to train and equip future engineers with the reality and dilemmas of modern life that they might face when they actually practice their profession. There is a widespread belief that teaching positive environmental attitudes and values is more important in bringing about change in environmental behaviour than the teaching of environmental knowledge is. Beringer (1990) discussed the use of narratives as an educational tool in strengthening environmental values and moral positions. Students are encouraged to tell their own stories of real-life environmental conflict and choice. Story telling encourages individuals to appraise the situation, identify the conflict, and take responsibility for their own stance. Responses from the teacher or peer group can then promote critical evaluation of the position taken and consideration of alternative solutions. Traditional values-education techniques may also be applied within a constructivist framework to help students become aware of and explore the consequences of their own values, for example, values clarification (Raths et al., 1966), values analysis (Metcalf, 1972), moral reasoning (Kohlberg, 1973), and values probing (Fien and Slater,1981). Such approaches would, however, need to be part of an integrated approach in which environmental knowledge and behavior are also addressed. There is some evidence that providing students with opportunities to apply environmental citizenship action skills successfully in the

community may also influence factors, such as locus of control and personal responsibility that have been shown to be influential in an individual's participation in environmentally responsible behaviour (Hines et al., 1987; Hungerford and Volk, 1990). R. R. Ballantyne et al. (1996) reported that a focus on environmental conceptions would not only enable the integrated development of environmental knowledge attitudes/values and behaviour but also provide a way of addressing students' commitment to environmentally responsible behaviour. Preparation of text-books and resource materials about environmental education can play an important role in building positive attitudes about environment. The basic human value 'man in nature' rather than 'nature for man' needs to be infused through the same (Kaushik and Kaushik, 2012)

#### VI. DESIGN OF ENVIRONMENTAL EDUCATION SUBJECT CURRICULUM FOR ENGINEERING EDUCATION

In majority of cases even today, engineers are being trained with an inadequate awareness of social, economic and legislative aspects of environmental factors which will play an ever-increasing role in their professional career. There is a great diversity of problems within the various branches of the engineering profession. Some of the disciplines are obviously more closely connected with the environment than others. Example chemical engineering, civil engineering, mining engineering and biotechnology are closely connected with environmental education. The working environment problems common to all engineering disciplines and is extremely important to know, because the worker is more directly exposed to hazards than are members of the public. The engineer has to know the effects of toxic substances on people, plants, animals, and the environment generally and be able to take precautions to minimize them. Example firemen, must know in advance what to expect, whether they can use water, whether gas masks should be worn, whether there are chemical risks to eyes, skin, etc. all this needs good preparation and organization by the engineers and their scientific colleagues.

The meeting of experts on environmental aspects of engineering education and training, convened by UNESCO in 1974, made the following recommendation:

Education effort aimed at improving environmental understanding among engineers must usefully be directed towards education in the following three phases, set out in order of priority:

- In-career education and training of practising engineers should be promoted based upon short-term courses and examination of case studies involving the use of multidisciplinary principles;

- Undergraduate education of all engineers shall include ecological and environmental principle and studies aimed at a general understanding of environmental problems;

- Engineers intending to specialize on environmental impact should pursue suitably arranged post-graduate higher degree courses.

It is generally recognized that to achieve that outcome, environmental educators must provide students with opportunities to acquire the knowledge, values, attitudes, commitment, and skills needed to protect and improve the environment (UNESCO, 1977). The social aspects of environmental issues should be emphasized along with the scientific explanations because students tend to be more motivated when hearing real life stories. Teachers should implement appropriate instructional strategies that engage students in problem solving about the impact that humans on the environment. These strategies will assist students in thinking more about environmental problems and develop positive behaviours (Bell et al., 1998). Learning strategies like hands on activities, field trips, games, discussions, questioning and role playing are some of methodologies used in environmental education. Engineered solutions to improve standards of living are often indicator of the level of development of an area, but what needs to be emphasized is that such development should not be at the cost of the natural resource base and the environment in which we live. Every engineering student whether pursuing an environmental career or not, should be provided with at least a minimum understanding of environmental issues to produce engineers with the capability to protect natural resources and at the same time meet the needs of the community. Through introducing environmental issues with their training in engineering, engineers will develop the habit of considering the environment in all aspects of their professional work. The range of topics might include, corrective and preventive policies of pollution control, administration and environmental law, environmental impact assessment, the changing nature of cost-benefit analysis, technologies for waste water treatment, technologies for air emission control, technologies for solid waste disposal, techniques for noise reduction, non-waste technologies and the working environment.

#### VII. HOW TO MAKE ENVIRONMENTAL EDUCATION MORE EFFECTIVE IN ENGINEERING EDUCATION: A PROPOSAL

Increasing technological development made life more comfortable and luxurious. Man is a small part in nature. With technological development man is trying to imitate nature. Engineers are technology developers since engineering education should be used in such a way that they develop technologies without damaging environment. While studying about a particular topic or about a technology the environmental impact of that technology

and how to make that technology environment friendly, should be included in engineering curriculum. For example, 1) When mechanical engineering students studying about two stroke and four stroke engines, students should know about environmental impacts of two stroke and four stroke engines because four stroke engines are pro-environment than two stroke engines; 2) Civil engineering student while studying about cement and other construction materials they should know environmental impacts of construction materials and their safe disposal; 3) Electronic and communication Engineering (E.C.E.) course deals with communication systems. Wireless technology is playing a vital role in present day communication systems, example cell phones. Micro wave radiations are used in cell phone communication. It is presumed that the micro wave radiations of cell phones and cell phone towers effect birds, human beings and other living things in the environment. But these harmful effects not proved scientifically. Hence engineers with the knowledge of environmental education should find positive solutions for such problems.

4) Manufacturing of electrical and electronic devices cause lot of pollution and disposal of e-waste is also a big challenge. So Electrical and Electronic engineering students should know environmental impacts of e-waste. One should know how to make electronic devices by using environment friendly materials and how to dispose e-waste more environment friendly. This type of curriculum design will improve pro-environmental behaviour among engineering students and it will motivate the engineering students to think and design environment friendly products and their safe disposal in to nature. For example, the scientists from the Italian Institute of Technology are developing 'smart materials' with biodegradable materials that could lead to robots which can be decomposed like a human body once they've reached the end of their life-span (Science daily, 2016). Industries are main source of environmental pollution. Engineers play an important role in industrial activities. An engineer with good environmental knowledge can identify about environmental problems of his industry and he can find solutions for environmental problems. This can be possible when engineering curriculum correlate with environmental education.

### VIII. CONCLUSIONS

Nature is a source of immense of energy and plenty of resources. Sustainable development is a collective responsibility of every individual. Environmental education and value-based education play a key role in making the planet pollution free. Environmental education is not only useful to solve pollution problems but also useful to get good health because "all environment friendly habits are good for health". Example cycling is an environment friendly habit and cycling is also good for

health. Nevertheless, there are some draw backs for effective implementation of environmental education in engineering institutions. The following suggestions may be implemented to overcome these drawbacks.

Suggestions to be implemented to make environmental education more effective in engineering education:

1)Specialised / qualified faculty members should teach this subject because many environmental educators do not possess a strong subject based background in environmental education (Mehta Vs University Grants Commission, 2014); 2)Should give credits to environmental education and marks should be included in total marks (some institutions are not giving credits to environmental education); 3)Field trips should be conducted more effectively; 4)Conducting seminars with other engineering subjects; 5)Environmental education should make compulsory subject and environmental education should be treated as a part of engineering education; 6)Encouraging student to carry out environment related projects like solar energy, wind energy and Green buildings etc.

Environmental education curriculum should be designed to help engineering students to understand the environmental context of engineering work as well as the responsibilities of engineers to the society and the environment. Through such curriculum students will learn to take into account the interaction of technology with the environment so that technological advances will not cause environmental damage. As mentioned in previous sections of this article, education develop pro-environmental behavior which makes students to "think more environment friendly". Changing technology and needs of society are creating new branches and new subjects in engineering education. This situation made necessity to bring transformations in engineering education. When these transformations are made with environmental considerations sustainable development can be achieved. Hence environmental education play key role in engineering education transformations.

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