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# Green Curriculum Analysis in Technological Education

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## Abstract

With rapid industrialization and technological development, India is facing adverse affects of unsustainable pattern of production and consumption. Education for sustainable development has been widely recognized to reduce the threat of environmental degradation and resource depletion. This paper used the content analysis method to explore the extent to which green curriculum has been incorporated in engineering education. The *green curriculum index* suggests that Indian technological education is following vertical integration, with low emphasis on horizontal integration of green curriculum resulting into non-sustained green culture and environmental behaviour among the students. Furthermore, higher educational institutions should understand and accept the relevance of sustainable development rather than responding to the legitimate formality for creating a low- carbon and green economy.

**Keywords**: Technological education, sustainable development, green curriculum index, India

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## Introduction

In the present era, children are disconnected from nature. They must understand the challenges of climate change, biodiversity, unsustainable production and consumption patterns. In 'Our Common Future', also known as Brundtland Commission Report advocated the concept of Sustainable Development (SD) as ecological preservation, economic viability and social justice (WCED, 1987). The report pointed out the significance of poverty eradication, principles of intergenerational and intra-generational equity, link between a healthy economy and healthy environment and limitations set by the carrying capacity of the environment (WCED, 1987). The notion of sustainable development was further popularized in the Rio Earth Summit where Agenda 21, Chapter 36 highlighted the role of education in meeting the needs of the present without compromising the ability of future generations to meet their needs (UNCED, 1992).

Education for Sustainable Development (ESD) was the key outcome of the Rio Earth Summit held in 1992. ESD includes key sustainable development issues like climate change, disaster risk reduction, biodiversity, poverty reduction, sustainable production and consumption. It has been seen as a major contributor towards the achievement of sustainable future through promoting awareness, developing values and influencing behaviour. ESD consequently promotes competencies like critical thinking, imagining future scenarios and making decisions in a collaborative way, particularly in professional and technical education (Mulà and Tilbury, 2009). With the progress in Education for Sustainable Development (ESD), a co-evolution of pedagogy has occurred where sustainable development is included at all levels of education through greening of the curriculum.

Greening curriculum needs genuine investment as it encourages environmental awareness as well as empowers participation in minimizing adverse environmental impacts. In 1991, Honourable Supreme Court of India mandated Environmental Education (EE) in all undergraduate programs to develop more environmentally sensitive and responsible citizens of the country. This directive has made Environmental Education (EE) compulsory in almost all undergraduate courses accounting for 85 per cent of students' enrolment in higher education in India. In December 2002, United Nations (UN) at its 57$^{th}$ session proclaimed the time period between 2005 and 2014 as Decade of Education for Sustainable Development (DESD). The objective behind DESD was to integrate the principles, values and practices of sustainable development into all aspects of education and learning. Since its inception in 2005, DESD has been a catalyst to promote the agenda for change in support of education for sustainable development (ESD) in the country (Mulà and Tilbury, 2009). During the decade, a growing interest has been observed among many universities and higher educational institutions (HEI's) in embedding sustainable development into their curricula.

### Relevance of Green curriculum in Technological Education

Technological education plays a vital role in emerging economy, like India. The acquisition of knowledge, skills and abilities in an undergraduate level are aimed to develop individuals with the right attitude and competency to compete favourably in the global society. An increase in technocratic ideology expands human power on technical control which significantly contributes to environmental and social problems resulting in the emergence of discourse about sustainable development (Pavlova, 2009). It is believed that green curriculum in technological education would enable an individual to become more resourceful and productive citizen of the society. But still, there is a long way for many technological institutions to understand and accept the relevance of sustainability as an integrated part of their course curriculum.

Technological education curriculum is generally based on disciplinary specialization and reductionist thinking resulting in unbalanced, over-specialized and mono-disciplinary education (Lozano, 2010). Lozano (2010) have proposed different approaches ranging from limited coverage in an existing module, specific SD modules, discipline-oriented modules with integrated SD topics and SD as an optional specialisation within a course. Horizontal and vertical integration methods are also

recognized for effective incorporation of green curriculum into technological education (Ceulemans and De Prins, 2010). When green curriculum is integrated into several courses is called as horizontal integration, while vertical integration involves the addition of new sustainability course or courses into an existing curriculum.

The study investigates the extent to which green curriculum is practised in technological education in Indian university.

### Delhi Technological University (DTU) Overview

Delhi Technological University (DTU), formerly known as Delhi College of Engineering (DCE), was established in 1941 as Delhi Polytechnic. Previously, the institution was under the control of the Government of India, but in 2009, it was given a state university status. It is believed that national capital represents specimen of the changes taking place across the country. Therefore, the research wisely considered Delhi Technological University for the purpose of the study.

The undergraduate engineering program (BTech) forms an integral part of the university. BTech is comprised of 13 different disciplines (Appendix 1). Each discipline serves various areas of engineering. The duration of the degree is four years including eight semesters of six months each.

## Methodology

### Data Collection

The research adopted content analysis method to study green curriculum in engineering program of Delhi Technological University. Content analysis has been defined as the study of recorded human communications or written information (Babbie, 2001). Data relies on module information (syllabus) available on the university's website in the month of May, 2015. Twenty four keywords has been listed denoting green curriculum in engineering course curriculum as mentioned in Table 1. The curriculum obtained from the website has been critically scrutinized, based on the selected keywords to examine each discipline's contribution towards sustainable development.

Table 1 Keywords to assess contribution to green curriculum

| | | |
|---|---|---|
| Green environment | Productivity | Biodiversity preservation |
| Environmental impact analysis | Future capability | Ecological implications |
| Waste recycling | Economic feasibility | Disaster management |
| Pollution control | Sustainability | Competitive advantage |
| Quality control and assurance | Use of bio-products | Ethical standards |
| Energy conservation | Cleaning process | Social welfare |
| Cost efficiency | Intellectual Property Rights | Personnel management |
| Health& safety | Risk assessment | Information and communication technology |

## Result and Discussion

### Curriculum description

While examining the course, it is manifest that the subjects has been categorized into three groups namely core, electives and open electives. Core subjects are compulsory for respective disciplines, whereas in case of elective and open elective, a selective number of subjects can be opted from a given number of choices.

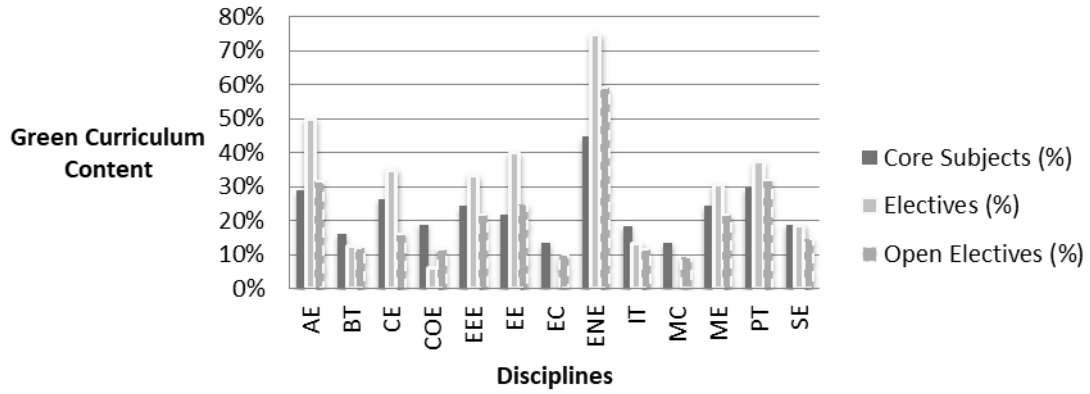
## Construction of Green Curriculum Index

### *Subject-wise green curriculum analysis*

Figure 1 illustrates three categories of subjects, i.e. core, elective and open elective along with their respective percent of green curriculum. It presents that the core subjects and open electives for all the disciplines embed almost a similar percentage of sustainability content whereas the scenario differs for elective subjects. The sustainability content variation is highly erratic between the elective subjects. Electronics and communications (ECE), mathematics & computation (MC) are two branches whose green consideration found to be incredibly low, with a slightly higher result for computer engineering (CE). Even core and open electives do not reflect a pleasing green concern.

The concept of sustainability needs to be incorporated into every technical facet of engineering curricula likewise designing buildings and structures, construction of machines, ICT applications and preparation of development plans. In mathematical analysis, environmental cost aspect should be considered to validate the significance of the model or project. This can be done by considering "Environment Adjustment Value (EAV)" i.e. a threshold value below which a project should not be considered as it may prove a threat to the environment. Technological advances should not be made at the expense of natural resources; therefore engineers must be aware of the safety measures for compensating the environmental uncertainties established with their projects. Therefore, all subjects irrespective of core, elective and open elective must emphasize on sustainability content to reduce the threat of environmental deterioration with increasing technological development.

**Figure 1: Subject-wise green curriculum incorporation**




### *Year-wise green curriculum analysis*

Further analysis has been done to evaluate green curriculum of each discipline on a yearly basis (see Table 2). In the first year, sustainability orientation is same, as the subjects and the content of teaching for the first two semesters are common in all disciplines. Applied chemistry, fundamentals of information technology, basic mechanical engineering and environmental sciences altogether contains 33% green curriculum in the first year. In second year, the average contribution accounts for 18 percent. During this year, electronics & communication engineering (ECE), mathematics & computation (MC) demonstrate the lowest contribution (8%) whereas environment engineering (ENE) exhibits a higher and consistent green curriculum (33%). It further decreases in third year and many disciplines present nil contribution, including biotechnology (BT), computer engineering (COE), electronics and communication engineering (ECE), mathematics and computing (MC) and software engineering (SE). In fourth year, the contribution increases to 22 percent but disciplines like biotechnology (BT), electrical engineering (EE), electronics and communication engineering (ECE),

information technology (IT), mathematics and computing (MC), mechanical engineering (ME) cease on its sustainable contribution (see Table 2).

Table 2 Green curriculum index (year-wise)

| Disciplines | 1st year (%) | 2nd Year (%) | 3rd Year (%) | 4th Year (%) |
|---|---|---|---|---|
| AE | 33 | 25 | 30 | 25 |
| BT | 33 | 17 | 0 | 0 |
| CE | 33 | 17 | 30 | 25 |
| COE | 33 | 17 | 0 | 33 |
| EEE | 33 | 25 | 10 | 33 |
| EE | 33 | 17 | 20 | 0 |
| ECE | 33 | 8 | 0 | 0 |
| ENE | 33 | 33 | 50 | 100 |
| IT | 33 | 17 | 10 | 0 |
| MC | 33 | 8 | 0 | 0 |
| ME | 33 | 17 | 30 | 0 |
| PT | 33 | 17 | 40 | 33 |
| SE | 33 | 17 | 0 | 33 |
| Average contribution (in %) | 33.00 | 18.08 | 16.92 | 21.69 |

From the above analysis, it has been found that environment engineering (ENE) maintains its perseverance to green curriculum where it reaches its extreme contribution in fourth year. Polymer and chemical technology (PT) follows environmental engineering (ENE) in its green participation with a great variation. Electronics & communication (ECE), mathematics & computation (MC) and biotechnology (BT) are the disciplines which remain on its lower green profile. These disciplines express outrageously lowest contribution in their last two years. It can be concluded that sustainability has been emphasized in the first year of the program which changes indifferently for rest of the years.

Table 3 Green curriculum index (discipline-wise)

| Disciplines | Total Subjects | Subjects with green curriculum | Contribution to green curriculum (%) | Analysis of clustering |
|---|---|---|---|---|
| ENE | 64 | 35 | 54.68 | A |
| PT | 53 | 17 | 32.07 | B |
| AE | 73 | 21 | 28.76 | B |
| CE | 207 | 55 | 26.57 | B |
| EEE | 74 | 17 | 22.97 | B |
| ME | 64 | 14 | 21.87 | C |
| COE | 69 | 15 | 21.73 | C |
| SE | 69 | 15 | 21.73 | C |
| EE | 77 | 14 | 18.18 | C |
| IT | 77 | 12 | 15.58 | C |
| BT | 194 | 25 | 12.88 | C |

| | | | | |
|---|---|---|---|---|
| MC | 65 | 7 | 10.76 | C |
| ECE | 211 | 22 | 10.42 | C |

***Discipline-wise green curriculum analysis***

The total numbers of subjects in four years of the program are analyzed to measure each discipline's contribution towards sustainability. Biotechnology (BT), civil engineering (CE) and electronics & communication engineering (ECE) are the disciplines which provide choice for their students to select subjects of open elective from the open elective subjects offered in other engineering disciplines. As a result, these three disciplines have maximum number of subjects offered in their degree.

Mean value method has been used to derive the average green contribution of the curriculum undertaken. The contribution has been measured as a ratio of sustainability- focused subjects assessed on the basis of the selected keywords and total number of subjects in a particular discipline. Green curriculum index of the engineering disciplines of Delhi Technological University (DTU) is presented in Table 3. It is found that green curriculum is offered in the university engineering curriculum. But maximum number of disciplines exhibit low green curriculum incorporation in their syllabus. Thirteen engineering disciplines of the university are clustered into three groups of greening levels. The order of greening extent is A> B> C. 'A' denotes disciplines which incorporates more than fifty percent of green curriculum, 'B' denoting 25 to 50 percent contribution and 'C' include disciplines contributing less than twenty five percent. Environmental engineering (ENE) is highest in green curriculum and solely belongs to level A. The third cluster C contains nine disciplines which really need to work hard towards the path of sustainability.

## Conclusion

Successful integration of sustainability principles and methods into engineering curricula requires a systemic change in our approach to education. Sustainable development is not just another topic to be considered in the curriculum, but competence-oriented approaches should be adopted in technological education. Students must be equipped with higher-level cognitive and critical thinking skills towards the transition of low-carbon economy, rather than a theoretical knowledge on sustainable development.

The results revealed that DTU introduced environmental engineering (ENE) as an optional specialization but green curriculum is not sufficiently integrated horizontally in its engineering curriculum. Adding a new course with sustainability content into a curriculum may be isolated as it does not encourage sustainability incorporation into professional designs and practices (Peet et al., 2004). However, horizontal integration is considered to be essential for fundamental concepts and principles related to sustainability. The integration of sustainability into existing courses may aid students in viewing sustainability in a systemic and holistic manner by demonstrating how sustainability and technical content can be blended to create sustainable designs (Ceulemans and De Prins, 2010). Moreover, it seems that incorporation of environmental studies in engineering curriculum is done only to fulfil the legitimate formality mandate by the highest court of the country. Green curriculum should be practised throughout the engineering program at a continuous and consistent pace to ensure environment responsive behaviour among the budding engineers and creating a just and sustainable world.

Engineering curriculum requires revision for sustainability integration in Delhi Technological University. The relevance of green curriculum should be understood by the University for infusing sustainability into the institutional culture. Technical University of Catalonia (UPC), University of Tokyo (Todai), Teri University are few examples which can be followed to integrate green curriculum in the present course structure. Ministry of Human Resource development (MHRD), University Grant

Commission (UGC) and All India Council for Technical Education (AICTE) should pay more attention regarding incorporation of green curriculum in engineering education. Industry, government and local communities can encourage universities to revive its curriculum towards developing low-carbon economies.

Appendix 1

Disciplines in B. Tech in DTU

| Code | Discipline's Name |
|---|---|
| AE | Automobile Engineering |
| BT | Biotechnology |
| CE | Civil Engineering |
| COE | Computer Engineering |
| EEE | Electrical and Electronics Engineering |
| EE | Electrical Engineering |
| ECE | Electronics and Communication Engineering |
| ENE | Environmental Engineering |
| IT | Information Technology |
| MC | Mathematics and Computing |
| ME | Mechanical Engineering |
| PT | Polymer Science and Chemical Technology |
| SE | Software Engineering |

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