Reasons and objectives for Life Cycle Engineering at an Undergraduate Level

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Abstract

Life Cycle Engineering (LCE) is a label used to describe Environmental Engineering in the areas of Design Engineering and Production Engineering. In our changing society it is important to introduce LCE to all young engineering students at an early stage. This paper presents reasons for the need to do this in the first year of university education. Objectives and points that need to be emphasized are included.

Keywords

Life Cycle Engineering, education, undergraduate

1 INTRODUCTION

This paper discusses the obvious need for education in LCE and suggests this must be done in the first year of university education. LCE in not discussed in first year engineering studies. Deciding what to include in an Environmental course has been discussed elsewhere [1].

Although there are many approaches to teaching Environmental Engineering, in the end, all approaches have the objective to decrease the impact of a design upon the environment. This content of this paper is based upon experience gained in teaching LCE for the last eight years in the Faculty of Applied Science at Queen's University at Kingston Ontario, Canada.

There is a need to create an awareness of the environmental impact of products, especially in design courses. This paper suggests an awareness of product impact upon the environment must be created at an early stage in undergraduate education and that it must be core to an engineering program.

2 STUDENT AWARENESS IN SECOND YEAR UNIVERSITY

One continually hears that:

- We are polluting,
- Pollution must be curbed,
- There is too much garbage,
- There will be an energy shortage,
- Climate change and Global Warming is occurring,
- That landfills are, increasingly, a problem.

It is known also that 70 percent of product costs are decided early in the design stage [2]. This can be extended to environmental impacts, where it can be observed that if we get the design right, at the beginning, environmental impacts can be reduced by an estimated 70 percent [3]. Therefore the environmental impact of a product must be addressed at the beginning of the design stage and at the beginning of design engineering education.

Do University students understand that products have an environmental impact?

The lack of awareness and concern by students about environmental impacts of products became apparent in a recent survey in a second year design course. The second year design course [4] has an enrolment of 160 second year students who are beginning to learn about design. This is a project-oriented course with all work being done in groups of six. After six weeks a major design project must be judged and marked. There are eight graduate student teaching assistants, TAs, who assist in grading the projects. Each design project is judged on: originality, resources, environmental impact, convenience, aesthetics, predictability, simplicity, durability and performance.

Both students and TAs were polled about how they thought the weighting should be for judging of the design projects. Figure 3 shows the result of that poll. It can be seen that environmental impact is the least concern for students and for TAs the least concern is aesthetics. In general environmental concerns are low for both groups. Both the undergraduate students and graduate students [TAs] do not have a requirement to take an LCE course, which includes information on environmental impacts.

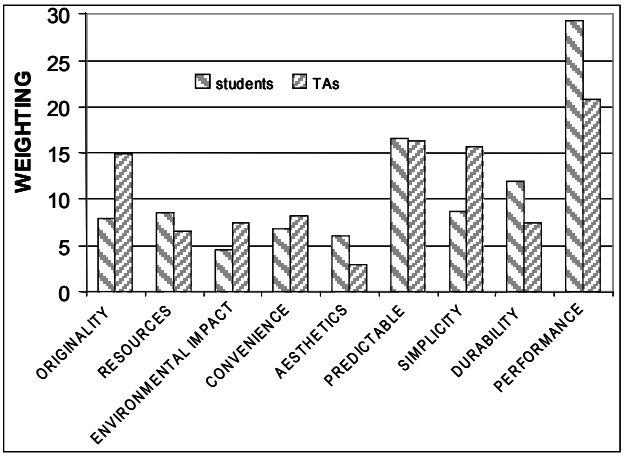

Figure 1: A comparison of the responses of students and TAs on how judging criteria for midterm projects in a second year compulsory design course [4] should be weighted. The response includes 160 students and 8 TAs.

3 CHANGES IN DESIGN AND MANUFACTURING

Changes are occurring at a fast pace in manufacturing and design. The ability to manufacture at much smaller

scales will create new opportunities in design. This will also create new environmental challenges in the future.

Products consist of one or more parts. All components and products are designed and then manufactured. Component products can be:

- single components (nail, bolt, fork, coat hanger, etc.).
- assemblies of many components (ball point pens, automobiles, washing machines, etc.).

Table 1 gives examples of the number of parts in some products [5].

Table 1. Examples of the number of parts in some products [5], circa 2000.

Product	Number of Parts
Rotary Lawn Mower	300
Grand Piano	12,000
Automobile ca. 2000	15,000
C-5A transport plane	> 4 million
Boeing 747-400	> 6 million

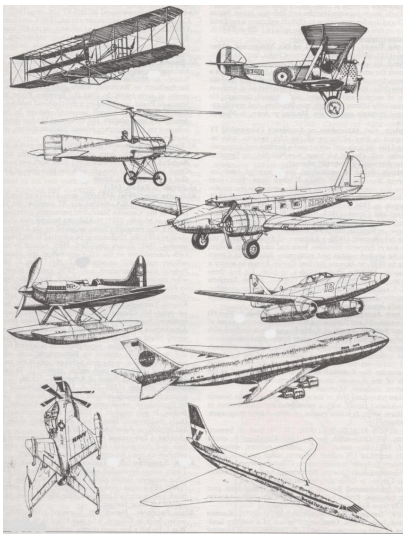

Figure 2: An illustration of the changes that *occurred in aircraft in the 20th century. [6]*

The airplane is a perfect example of how products have increased in complexity, with concomitant increase in the number of parts. Figure 2 shows examples of aircraft from the Wright Brothers onward.

The number of components per product have changed dramatically with time. Both figure 3 and table 2 illustrate this for a variety of products. Also shown in figure 3 is the prediction that, with the introduction of Nanotechnology, there will be an order of magnitude increase in the number of parts per product [7]. This can be illustrated simply by considering the environmental effects that Nanotechnology may have upon the environment; they are unknown. For example, the sizes of Nanotechnology particles are those of blood cells [8]. At this scale, the effects of many elements and chemicals are unknown, and tests are not conducted.

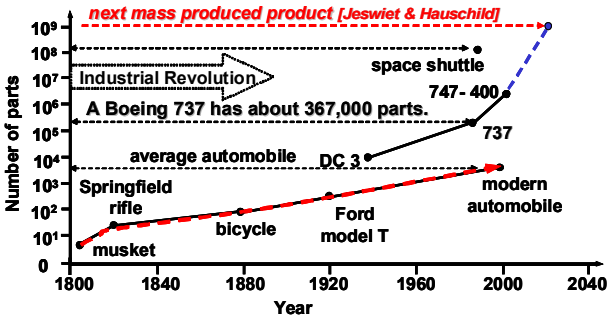

Figure 3: The increase in the number of parts per product with time [7].

4 10 POINTS THAT NEED TO BE EMPHASIZED

It is obvious that products will continue to be demanded, designed and made. These products will have environmental impacts that must be kept to a minimum. With the foregoing in mind, the following points must be included in a first year engineering design course [9]. They are:

Point 1: Environmental problems occur because people want and need products; ie: there are Markets.

Point 2: Products are Designed and Manufactured by Design / Manufacturing Engineers.

Point 3: Consumer numbers will not reduce and their habits will change dramatically.

Point 4: Environmental problems are human centred & created.

Point 5: In modern society, mass production is the norm.

Point 6: Engineers Design and Manufacture all products, from screws to fuel cells.

Point 7: There is an environmental impact for all design and manufacturing processes.

Point 8: It is important to get the design right at the beginning.

Point 9: The designer must think about potential environmental impacts at all design stages.

Point 10: Treat nature fairly or suffer potential environmental consequences.

5 LCE COURSE OBJECTIVES IN FIRST YEAR

With the foregoing points of emphasis there must be course objectives. These include [1]:

- a recognition of the importance of the environment in social welfare.
- the importance of the environment in human and long term economic welfare.
- a recognition of the type and major stressors upon the environment.
- learning the rudiments of environment impact assessment.
- gaining a basic understanding of environmental management systems.
- understanding how risk assessment affects management decisions and public perception.
- learning about tools for the EcoDesigner that can be used in Design for the Environment.

6 SUMMARY

The need to expose Engineering Design students to LCE principles at an early level and the reason for the need have been discussed.

Points that need to be emphasized for Engineering Design students have been listed and objectives that need to be included have been included.

The Romans recognized there are consequences to how we treat nature: Naturm expellas furca, tamen usque recurret [Horace] - You may drive out nature with a pitchfork, yet she'll constantly return. Society, EcoDesigners and Engineering Design students also need to recognize this.

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