Incorporating Total Cost Assessment into a Course in Chemical Process Analysis and Design

Final Report

by

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to the

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Executive Summary

The objective of this project was to prepare, use, evaluate, and disseminate a module on total cost assessment for use in a course in chemical process analysis and design. Most chemical engineering programs have one or two capstone courses on the analysis and design of chemical processes. As part of these courses, students design chemical plants and perform economic analyses of their operation. Normally, the profitability analysis performed on these plants involves only capital costs and operating costs. None of the available texts introduce the students to the concept of total cost assessment, a methodology based on the life cycle approach, which considers, in addition, all environmental and health costs associated with the project. The module prepared is intended to remedy this deficiency.

Introduction

At the University of South Carolina, the chemical engineering undergraduate curriculum culminates in the senior year in a design sequence consisting of two courses: ECHE 465 Chemical Process Analysis and Design I in the fall semester and ECHE 466 Chemical Process Analysis and Design II in the spring semester. This work concerns the first of these two courses. This is a required course offered every fall and taken by all our seniors, 35 to 40 students per year on the average. Since most chemical engineering programs have a similar design course, the total cost assessment module developed as a result of this project could be easily used in similar courses in other schools.

Course Objectives

The course objectives of ECHE 465 Chemical Process Analysis and Design I are listed below:

1. Students will demonstrate the ability to develop a flow sheet for a simple process.
2. Students will demonstrate the ability to perform profitability analysis on simple processes.
3. Students will work in groups and report both orally and in writing on the flow sheet, major pieces of equipment, and economic analysis of a simple process.
4. Students will independently gather information and present in an individual written report their conclusions and recommendations on a problem with global and societal implications.
5. Students will gain an understanding of professional and ethical issues in engineering.

In the past, the economic analysis mentioned in the second and third objectives of the course has included only traditional capital and operating costs, such as the costs of equipment, labor, raw materials, waste disposal, etc. The Total Cost Assessment Methodology (a 168-page publication available free from the Center for Waste Reduction Technologies of the American Institute for Chemical Engineers at http://www.aiche.org/cwrt/projects/cost.htm) calls the costs already mentioned Type I costs. Total cost assessment includes these costs, but in addition considers all other environmental and health costs, which it classifies into four additional types of costs:

Type II. Indirect and Hidden Costs. These include reporting costs, regulatory costs, and monitoring costs not normally considered in the standard economic analysis.

Type III. Future and Contingent Liability Costs. These include costs due to potential fines, penalties and future liabilities for non-compliance with environmental regulations, remediation, personal injury, property damage, and industrial accidents.
Type IV. Internal Intangible Costs. These are costs borne by the company resulting from a deterioration of customer acceptance, worker morale, union relations, and community relations.
Type V. External Intangible Costs. These are costs borne by society resulting in an increase in housing costs, the degradation of habitat, etc.

The total cost assessment methodology is based on the life cycle approach and is defined as the identification, compilation, analysis, and use of environmental and human health cost information associated with a business decision. It is important for chemical engineers to consider all these costs (the total cost) before a chemical plant is built or before a modification to an existing plant is made. It is possible that a different choice of product or of process would be made if all costs were taken into account than if only Type I costs (those included in the course at present) were taken into account.

Proposed Work and Progress to Date

The objective of this project was to incorporate total cost assessment concepts into the first semester course in chemical process analysis and design. The proposed work consisted of the preparation of a module, the use of the module, the evaluation of the module, the dissemination of the module, and the preparation of the reports.

A. Preparation of the Module.

The following was accomplished during the summer of 2001.

1. Develop the notes for one lecture that introduces the concept of total cost assessment. These notes are presented in the attached Power Point document. Click here to view this document.
2. Develop homework problems involving the use of total cost assessment concepts. These problems are presented in Appendix A.
3. Develop a questionnaire for the evaluation of the module by the students in the course. The questionnaire is presented in Appendix B.

The material for the module was based mostly on the Total Cost Assessment Methodology handbook already mentioned, but other sources were consulted as well.

B. Use of the Module

The module developed during the summer will be used when the course is taught in the fall of 2002.

C. Evaluation of the Module

The module will be evaluated in three ways:

1. Self-evaluation by the principal investigator after its use.
2. Peer evaluation by other faculty members.
3. Evaluation by the students using the questionnaire developed.

D. Dissemination of the Module.

The lecture notes are being posted in the Sustainable University web page together with this report. In addition, the principal investigator will submit an article for publication in Chemical Engineering Education magazine, which is received by most chemical engineering faculty in this country. The article will describe the introduction of sustainability concepts into this course made possible by the work proposed here and by the work performed previously as the result of another Sustainable Universities Initiative mini-grant (Incorporating Sustainability Concepts into a Course in Chemical Process Analysis and Design).

Budget

The budget consisted of summer salary for the principal investigator during the summer (seven working days) and a small amount for supplies.

APPENDIX A

Homework problem

Following the procedure of the case example in Appendix 3 of the Total Cost Assessment Methodology (published by the Center for Waste Reduction Technologies of the American Institute for Chemical Engineers and available at http://www.aiche.org/cwrt/projects/cost.htm), compare the total cost to the University of South Carolina of requiring all undergraduates to live on campus to the total cost of the current mode of operation. List all your assumptions.

APPENDIX B

Questionnaire for the evaluation of the modules

Student evaluation

The following questions will be added to the course evaluation survey administered at the end of the fall 2002 semester. Each of the questions is to be answered by choosing one of the following five options: Strongly Disagree, Disagree, Neutral, Agree, or Strongly Agree.

1. My awareness of environmental issues in engineering has increased as a result of this course.
2. The lecture and homework on total cost assessment increased my awareness of the environmental impact of business decisions.