

2006-1315: THE ROLE OF INDUSTRY IN SUPPORTING EDUCATION IN ENVIRONMENTALLY RESPONSIBLE ENGINEERING

Andrew Borchers, Kettering University

Andrew Borchers, DBA is an associate professor of Information Systems at Kettering University. Prior to teaching, Andy spent 21 years working as an IT manager for GM and Electronic Data Systems. His academic interests include information technology, entrepreneurship and environmental sustainability. Andy serves on the editorial board of Information Resources Management Journal and is an associate editor of the Journal of Cases in IT.

David Rinard, Steelcase, Inc.

Dave Rinard, M.S., is director of Corporate Environmental Performance for Steelcase, Inc., the global leader in the office furniture industry. Dave is responsible for overseeing the company's environmental initiatives and implementing corporate environmental strategy. Dave currently serves on the board of directors of the West Michigan Sustainable Business Forum and on the advisory boards of the University of Michigan's Center for Sustainable Systems, the Aquinas College Sustainable Business Program, and the Kettering University Industrial Ecology Program.

Trevor Harding, Kettering University

Trevor Harding, Ph.D., is associate professor of Industrial and Manufacturing Engineering at Kettering University where he teaches courses in engineering materials and manufacturing. Dr. Harding's research interests include wear phenomenon in orthopedic implants, ethical development in engineering undergraduates, and pedagogical innovations in environmental education. Currently, Trevor serves on the ERM Division Board of Directors and on the Kettering University Center for Excellence in Teaching and Learning Advisory Board.

Terri Lynch-Caris, Kettering University

Dr. Terri Lynch-Caris, Ph.D., P.E., is an Assistant Professor of Industrial and Manufacturing Engineering at Kettering University. She serves as the Co-PI for the NSF project titled "Development of a Course in Environmentally Conscious Design and Manufacturing for Undergraduates" and will team-teach the course once developed. Her areas of interest in teaching and research include ergonomics, statistics, and work design. She also serves as the treasurer for the Industrial Engineering Division of ASEE.

The Role of Industry in Supporting Education in Environmentally Responsible Engineering

Abstract

Achievement of a sustainable future implies a collaborative effort between a variety of stakeholders including industry, government, and academia. We are traveling in unfamiliar waters where the course is not always clear and the goals are sometimes daunting. To develop the environmental wisdom we need to help us know the "right answers" we must bring together the knowledge we get from our academic pursuits with the experience we obtain through trial and error. Bringing together the academic world and the business world not only helps us solve the immediate engineering need, it more importantly builds a partnership that will produce greater lasting value through students (future employees) who are attuned to the market demands for improved environmental performance in both business practices and products.

This paper describes a new collaborative effort between Steelcase, Inc. and Kettering University that will prepare future engineers, managers, scientists, and policy makers for a workplace that places greater emphasis on conducting business within a framework of environmental and social responsibility. Since its founding in 1912, Steelcase, Inc. has approached its business from a "values-driven" perspective focused on the underlying premise of how a responsible business should conduct itself. As such, Steelcase, Inc. has been a leading company in promoting sustainable business practices both within the corporation and among a variety of other constituents. Kettering University (formerly GMI Engineering and Management Institute) has been preparing engineers and managers for the workforce since 1919, emphasizing the importance of leadership, integrity, and practical experience as the keys to success in the workplace. Together these organizations, along with other partners, are committed to demonstrating the practical need for enhanced education in issues of sustainability and social responsibility.

Funding for this project comes from the National Science Foundation DUE-0511322.

Introduction

Industry more than ever is facing challenges in the globally competitive marketplace. Thomas Friedman in his book The World Is Flat [1] talks about the forces that are changing the competitive landscape and the need for business and society to innovate more than ever to stay competitive. Friedman also highlights the need for increased learning and skill development as a way to survive in this rapidly changing and competitive climate.

Friedman cites statistics showing a significant decline in US students pursuing science and engineering educations. In a New York Times article [2] Friedman quotes a joint report of the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine that says: "Having reviewed the trends in the United States and abroad, the committee is deeply concerned that the scientific and technical building blocks of our economic leadership are eroding at a time when many other nations are gathering strength. We are worried about the future prosperity of the United States. We fear the abruptness with which a lead in science and

technology can be lost and the difficulty of recovering a lead once lost---if indeed it can be regained at all.” If it continues, this loss of creative horsepower will stifle innovation and put the competitiveness of US firms in serious jeopardy.-----

-

At the same time, we are seeing global environmental issues take on increasing significance putting pressure on our resource availability and our life support systems. The growing population coupled with rapid industrialization in these developing nations will increase these pressures to design and produce the products and services we all use in a more sustainable way.---

-

Many examples of the shift to more sustainable product life cycles exist. European automakers, for example, face auto recycling requirements [3] that will soon emerge in the U.S. Office furniture makers face similar challenges in using environmentally friendly practices and materials. One author [4] notes that “sustainability may be the central element of the most successful steps in addressing environmental concerns” in the office furniture market. As a practical matter, for example, the vast majority of requests for proposal in this market require environmental responses.--

-

Engineering organizations have recognized the need to address sustainable economic development, yet curricular changes are only beginning to take place. According to the National Academy of Engineering, the growing environmental crisis means that “Engineering practices must incorporate attention to sustainable technology, and engineers need to be educated to consider issues of sustainability in all aspects of design and manufacturing” [5]. Yet many universities like Kettering University do not offer meaningful instruction in this area, and what does exist tends to emphasize air, water, and soil pollution rather than the environmental dimensions of manufacturing and product design [6].-

-

Industry-/academic partnerships are a creative way to address these pressures. By creating partnerships, both parties seek to raise awareness of the challenges business and society face and to harness the creative talents of the next generation of engineers in solving these issues.---

Kettering Industrial Ecology Team (KIET)

-

Late in 2003 a group of faculty at Kettering University (formerly GMI Engineering and Management Institute) in Flint, Michigan began meeting to study the topic of industrial ecology. Kettering has a long history of close cooperation with industry and currently works with some 600 co-op employers in its undergraduate program. All undergraduate students are required to complete significant work experience in addition to academic studies in order to earn engineering, science or management degrees.---

-

As KIET evolved through 2004 and 2005, it came to include a number of parties. Initially, faculty representatives from all Kettering University departments joined in the effort. Engineering faculty logically fit in the team given their focus on teaching engineering design, manufacturing processes and material selection. Science faculty, particularly in environmental chemistry, added yet another dimension to the team. Faculty from liberal studies brought a focus on ethics and industrial history. Last, business faculty added another key dimension, namely that

students-need-to-understand-the-economic-consequences-and-learn-to-account-for-the-life-cycle-cost-of-various-process-and-product-designs.---

-

Early-on-KIET-recognized-the-need-to-develop-a-broad-based-community-to-support-its-efforts.--In-addition-to-Kettering-faculty,-KIET-identified-academic-experts-from-other-institutions-to-work-with-the-team.--KIET-also-recruited-a-group-of-industry-experts-from-its-base-of-co-op-employers.--In-particular,-several-members-came-from-the-automotive-and-office-furniture-industries-as-these-are-major-employers-of-Kettering-students-and-operate-in-close-proximity-to-Kettering's-campus.--KIET-also-recruited-Kettering-students-and-university-personnel-in-the-advancement-area-to-round-out-the-team.-

-

KIET Activities

-

In-order-to-advance-the-study-of-industrial-ecology-at-Kettering-University,-KIET-began-a-number-of-activities.--These-activities-reinforce-each-other.--

-

Speaker Series

-

One-of-the-early-success-stories-for-the-group-came-in-the-form-of-visiting-speakers-and-off-campus-tours.--In-bringing-speakers-from-industry-to-campus,-KIET-discovered-a-latent-interest-on-the-part-of-many-Kettering-students-in-the-field-of-industrial-ecology.--KIET-schedules-four-speakers-a-year,-one-for-each-12-week-term.--To-date-this-speaker-series-has-generate-well-attended-lectures-by-students.--Surveys-of-attendees-supports-the-notion-that-industrial-ecology-holds-great-interest-with-undergraduate-engineering-students.--These-speakers-are-able-to-reinforce-the-message-that-faculty-are-beginning-to-communicate-in-the-classroom,-namely-that-engineers-and-managers-not-only-have-to-create-products-that-meet-functional-and-marketing-demands,-they-must-also-create-products-with-smaller-environmental-footprints.--At-the-same-time-that-products-are-environmentally-sensitive,-they-must-be-profitable-in-the-competitive-marketplace.-

-

Course Development

-

Probably-the-most-significant-effort-that-KIET-is-involved-in-comes-in-the-development-of-curriculum.---With-advice-from-the-KIET-advisory-board,-faculty-at-Kettering-University-are-developing-a-combined-senior-level-and-graduate-level-course-in-industrial-ecology.--The-National-Science-Foundation-is-funding-this-effort-under-a-three-year-CCLI-grant.-

-

The-KIET,-working-with-their-advisory-board,-determined-that-a-useful-starting-point-for-this-project-was-the-Ford-Motor-Company-PAS-(Partnership-for-Advanced-Studies)-program.--In-particular,-KIET-believes-that-the-PAS-module-"Closing-the-Environmental-Loop"-is-an-excellent-base-for-adaptation-into-a-university-level-course.--Ford's-experience-in-high-schools-with-PAS-showed-it-to-be-effective-in-building-interest-in-STEM-(Science,-Technology,-Engineering-and-Mathematics)-among-high-school-students,-especially-female-and-under-represented-minorities.----

After-discussion-with-the-KIET-advisory-board-and-a-thorough-review-of-the-literature-and-the-Ford-PAS-curriculum,-KIET-identified-the-following-course-learning-objectives:-

-

- 1.) Understand-the-historical,-social,-legal,-and-ethical-issues-underlying-the-environmental-impact-of-goods-and-services.-
- 2.) Evaluate-life-cycle-analyses-of-products-and/or-processes-and-propose-strategies-for-minimizing-environmental-impact-while-still-meeting-design-and-economic-requirements.-
- 3.) Conduct-a-material-selection-with-the-goal-of-reducing-the-environmental-impact-of-a-product-and/or-process-while-simultaneously-reducing-material-costs.-
- 4.)- Employ- appropriate- tools- to- evaluate- the- environmental- impact- of- a- manufacturing- process- and- recommend- actions- to- reduce- both- this- impact- and- production- costs.-
- 5.) Analyze- and- propose- changes- to- a- product- design- that- result- in- enhanced- recycling,- reuse- and/or- remanufacturing- capabilities- with- consideration- of- the- economics- of- these- activities.-
- 6.) Identify-the-relative-merits-of-various-approaches-to-industrial-ecology-within-a-corporation.--
- 7.) Demonstrate-enhanced-critical-thinking-through-exhibiting-successful-application-of-problem-solving-strategies,-high-intellectual-standards,-and-the-traits-of-master-reasoners.-

-

KIET-is-designing-a-six-module-course-to-accomplish-the-objectives-listed-above.-The-intent-in-developing-this-course-in-modular-format-is-that-Kettering-University-may-elect-to-reconfigure-and-use-these-modules-in-multiple-venues,-including-continuing-education-for-industrial-clients.--Kettering-faculty-will-teach-the-modules-using-motivating-case-studies-and-active-learning-strategies.--These-methods-have-numerous-benefits-including-motivating-students-to-learn,-increasing-knowledge-transfer-[7],-encouraging-active-learning-[8]-and-introducing-ambiguity-into-decision-making-[9].---

-

There-already-exists-a-rich-body-of-case-studies-in-the-environmental-areas.--KIET-will-select-cases-from-the-existing-body-and-develop-new-case-studies-working-with-our-industrial-partners.--As-an-example,-the-Ford-PAS-project-uses-the-life-cycle-of-a-tennis-shoe-to-appeal-to-students.--Cases-on-Starbucks-Coffee-[10]-and-McDonald's-hamburger-wrappers-[11]-are-other-examples-that-students-can-easily-identify-with-and-that-illustrate-the-complex-tradeoffs-of-environmental,-financial-and-public-relations-factors-that-organizations-face.-

-

The-six-modules-for-Kettering's-new-course-include:--

- 1.)-Technology,-the-environment-and-industrial-ecology.--In-this-module-students-will-be-introduced-to-the-broader-historical,-social,-and-ethical-dimensions-of-industrial-activity,-paying-particular-attention-to-environmental-impacts.-Discussion-of-the-need-to-move-towards-a-sustainable-society-will-be-followed-by-introduction-of-the-notion-of-industrial-ecology-and-sustainable-business-practices.--Students-will-also-be-introduced-to-basic-environmental-science-and-specific-environmental-performance-metrics.-
- 2.)--Life-cycle-concepts-and-assessment.--This-module-presents-students-with-the-notion-that-environmental-impact-extends-beyond-production-to-include-material-extraction,-product-use,-and-end-of-use-strategies.--Students-will-discuss-life-cycle-stages-for-a-variety-of-example-products.--Strategies-for-assessing-the-impact-of-each-life-cycle-stage-will-be-presented-and-the-students-will-explore-the-advantages-and-challenges-associated-with-each.--
- 3.)--Material-selection-strategies-and-requirements.--In-this-module,-students-will-be-introduced-to-environmental-impact-measures,-industrial-standards-and-guidelines,-decision-making-strategies-that-can-be-used-for-material-selection,-and-computer-tools.-

- 4.)--Process-design-and-improvement.-Students-will-be-introduced-to-methods-of-identifying-the-most-damaging-part-of-the-process-flow-through-material-and-energy-balances.-Common-practices-for-reducing-energy-consumption-and-waste-will-be-discussed.-In-addition,-strategies-for-environmentally-sustainable-product-packaging-and-delivery-will-be-presented.-
- 5.)--End-of-use-strategies.--This-module-addresses-strategies-and-challenges-associated-with-reducing-the-environmental-impact-of-a-product-after-it-has-been-used-by-a-consumer-or-business.--Discussion-will-focus-on-re-use,-remanufacturing,-recycling,-and-disposal-options.--Design-for-recycling-tools-will-be-demonstrated-and-practiced-on-real-products.-
- 6.)--Environmentally-responsible-management.--This-module-will-present-current-best-practices-in-promoting-design-for-the-environment-within-the-corporation.--In-addition,-the-module-will-introduce-students-to-current-trends-in-environmental-management-systems,-green-supply-chains,-lean-manufacturing,-and-total-cost-accounting.-

Conclusion and Future Steps

Environmentally-responsible-engineering-is-an-emerging-topic-of-vital-interest-to-engineering-educators-and-to-employers-of-engineering-graduates.--This-field-is-inter-disciplinary-by-its-very-nature,-requiring-students-and-practitioners-to-consider-multiple-objectives-simultaneously.--Moreover,-as-an-emerging-field-of-practice,-students-and-faculty-need-to-work-closely-with-industrial-partners-to-ensure-relevance-and-currency.--Kettering-University's-KIET-effort-has-brought-together-experts-in-the-academic-and-the-industrial-world-to-create-appealing-academic-experiences-for-undergraduate-students.---

Beyond-the-initial-steps-of-bringing-speakers-to-campus,-creating-a-community-of-interest-and-creating-a-single-combined-undergraduate/graduate-course,-KIET-has-many-more-roads-to-travel.--First,-KIET-can-develop-additional-courses-to-provide-more-depth-of-study.--Such-efforts-are-likely-to-be-limited,-however,-given-the-already-"packed"-undergraduate-engineering-curriculum.--Second,-KIET-may-find-greater-success-in-introducing-industrial-ecology-topics-in-traditional-engineering-and-science-courses.--Third,-Kettering-University-as-a-co-op-school-can-identify-co-op-opportunities-for-students-that-need-environmentally-oriented-engineers.--Fourth,-Kettering-can-work-with-industry-partners-in-sponsored-research-and-student-focused-design-projects-and-competitions.--Fifth,-KIET-can-use-material-from-its-new-academic-course-in-offering-continuing-education-to-corporate-clients.--Finally,-KIET-can-develop-outreach-programs-focused-on-the-environmental-and-social-impacts-of-science-and-technology.--For-example,-KIET-has-already-identified-interested-groups-wanting-to-teach-industrial-ecology-at-the-K-12-level.--This-is-especially-important-as-Kettering-University-works-to-attract-students,-particularly-women-and-under-represented-minorities,-to-the-engineering-profession.---

References

- 1-Friedman,-T.The-World-is-Flat,Farrar,-Straus-and-Giroux,-New--York,-2005.---
- 2-Friedman,-T.-"Keeping-Us-In-The-Race"New-York-Times,-October-14,-2005.-

- 3-Kimberley,-W.,--“European-Vehicle-Manufacturers-Face-Recycling-Requirements”--
Automotive-Design-&-Production-Vol.116:-8;-2004,-pg.-20-22.--
-
- 4-Rowh,-M.-“Inside-the-Sustainable-Office”Office-Solutions, -Vol.22:3-May/June-2005,-pg.-22-25.-
-
- 5-National-Academy-of-Engineering,-“The-Engineer-of-2020:-Visions-of-Engineering-in-the-New-Century”.-The-National-Academies-Press,-Washington,-D.C.2004.-
-
- 6--Powers,-S.-E.,-Zander,-K.-Theis,-T.L.-and-Maclean-H.-“Incorporating-Industrial-Ecology-and-Sustainability-Concepts-into-Environmental-Engineering-Courses.”--Workshop-presented-at-the-AEESP/AEEE-2002-Education-and-Research-Conference.-Clarkson-Center-for-the-Environment,-2002.-
-
- 7-Bocker--“Is-Case-Teaching-More-Effective-than-Lecture-Teaching-in-Business-Administration?-An-Exploratory-Analysis.”-Interfaces, -Vol-17:5,-1987,-pp.-64-72.-
-
- 8-Kenney,-S.-J.-“Using-the-master’s-tools-to-dismantle-the-master’s-house:-Can-we-harness-the-virtues-of-case-teaching?”-Journal-of-Policy-Analysis-and-Management Vol-20:2,-2001.-
-
- 9-Banning,-K.C.--“The-Effect-of-the-Case-Method-on-Tolerance-for-Ambiguity”Journal-of-Management-Education - Vol 27:5,-2003.
-
- 10-Austin,-J.-E.-“Starbucks-and-Conservation-International,-Video”,-Harvard-Business-School-Publishing,-Boston,-2003.-
-
- 11-Svoboda,-S.-“McDonald’s-Environmental-Strategy”-retrieved-1/18/06-from-
<http://www.umich.edu/~nppcpub/resources/compendia/CORPpdfs>, -1995.-
-