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

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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.

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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.-----

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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.---

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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.--

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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].-

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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.---

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Kettering Industrial Ecology Team (KIET)

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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.---

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

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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].---

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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.-

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

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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

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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.---

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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.---

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