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

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Abstract-

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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.----

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

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Introduction

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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.---

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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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