

Introduction

The following sections describe the goals and activities associated with the Kettering Industrial Ecology Team (KIET) efforts at Kettering University. The sections are as follows: Part 1 contains the overall goals of the initial grant proposal as well as the result of those goals. Part 2 is the evaluation form for the advisory board with the results of the survey. Part 3 contains the pre/post test survey from students. Part 4 contains the assessment statement from the initial offering of the course.

Part 1 - Goals

Goal #1: Course Development

- A new course, IME540 Environmentally Conscious Design and Manufacturing, has been developed, approved by the undergraduate and graduate faculty committees and added to the elective course offerings for Kettering University students. IME540 was offered to Kettering undergraduate students during the Winter 2007, Spring 2007, and Spring 2008 terms
- Six course learning modules were presented in IME540 and taught by a multi-disciplinary team of six faculty members. The six course learning modules included (1) Historical, Social & Ethical Perspectives, (2) Life Cycle Analysis, (3) Materials Selection, (4) Manufacturing Process Design, (5) End of Use Alternatives, and (6) Environmentally Responsible Management. Formative assessment was performed throughout the initial offering with faculty input results shown in Part 4 below.
- A Green Chemistry Lab was added to the existing six modules to provide further technical content in the course as well as a hands-on lab experience. In the first offering of the course, students used chemistry to make (but not test) biodiesel. The formative assessment process enhanced this lab during the second offering. In response to student feedback, arrangements were made to test their biodiesel fuel in the Mechanical Engineering Advanced Engine Research Lab
- A set of course materials was prepared into a CD format including Powerpoint presentations, lecture notes, readings and quizzes. This CD was distributed to interested educators as one form of dissemination in Goal #6.
- The faculty who developed and taught the IME540 course won the “TRW/CETL Educational Scholar Award 2007” at Kettering University for the innovative pedagogical techniques used in the course.

Goal #2: Adaptation and Implementation of Ford PAS

- Adaptation of Ford Partnership for Advanced Studies as applied to multiple industries through the input of industrial stakeholders and advisors.
- The student group, Green Engineering Organization (GEO), was created as a catalyst for environmental activities for Kettering students. Among other activities, this group has initiated a recycling program and hosts guest speakers from the KIET advisory board and beyond who talk about environmental issues for the entire campus. In addition they hosted a “Focus the Nation” teach-in (Jan 31, 2008) and participated in “Green Week” (May 12-16, 2008) that highlighted efforts in the area related to sustainability.
- Outreach component included summer high school residence program for females. The Lives Improve Through Engineering (LITE) program is offered for high school females to encourage young women to pursue a career in engineering. A total of four topic areas are taught in this program and Sustainability was a new topic offered in 2007. A total of 77 females attended during the summer of 2007 and 2008 were taught by KIET faculty.

Goal #3: Incorporation of Input from Stakeholders

- Four advisory board meetings have been held at Kettering and at partner locations as summarized in the table below:

	Location	Date
1	Kettering University	September 30, 2004
2	Ford Motor Co	December 14, 2005
3	General Motors Corp.	October 1, 2007
4	Herman Miller	October 1, 2008

- Advisory board members were surveyed with assessment results summarized for Goal #5 and complete information shown in Part 2.
- Guest speakers from the advisory board have spoken to the entire campus community followed by small group discussions. The Student Group, GEO, has taken on the responsibility of organizing and advertising the guest speakers. A list of speakers is shown in the following table:

Name	Title	Company	Date
Dr. Robert Lehmann	Water Management	Michigan DEQ	August 27, 2008 November 3, 2008
Gerald Greer	Environmental Engineer	Global Engine Manufacturing Alliance	February 4, 2007 January 31, 2008
Partap C. Lall	Lake Wide Management Plan Environmental Engineer	EPA	November 7, 2007
David Rinard	Director, Corporate Global Environmental Performance	Steelecase	April 18, 2007 August 23, 2007
Keith Grass	CEO	David J. Joseph Co.	June 22, 2007
Gabe Wing	Design for the Environment Manager	Herman Miller	November 8, 2006 February 21, 2007
John Bradburn	Senior Environmental Project Engineer	GM	May 24, 2006 August 2, 2006
Bruce Conventry Jalonne Newsome-White	President, GEMA LLC and VP Chrysler LLC Environmental Engineer, GEMA	Global Engine Manufacturing Alliance (GEMA) Division of Daimler-Chrysler	November 4, 2005 February 24, 2006
Claudia Duranceau	Senior Research Engineer	Ford Motor Company	June 8, 2004 July 26, 2005

Goal #4: Integration of Course into Kettering Curriculum

- IME540 was offered as a senior elective across all disciplines. It has been integrated into several specialty programs as well as the new MBA program as an elective course.
- IME540 has been offered three times with enrollment information shown in table below:

term	year	enrollment	gender		Ethnicity					
			males	females	Caucasian	unknown	Multi-racial	international/foreign	Oriental/asian	hispanic
winter	2007	5	100%	0%	80%	20%	0%	0%	0%	0%
spring	2007	17	65%	35%	76%	0%	6%	12%	6%	0%
spring	2008	6	83%	17%	50%	17%	0%	0%	17%	17%

*Note that students have few opportunities to take elective courses in their various programs. IME540 is just one of many choices. Thus, to increase enrollment in this course faculty plan to offer IME540 online in winter 2009 and propose other ideas for integrating the ideas across the curriculum.

- Based on industrial advisory board input, faculty were encouraged to more fully embed the environmental perspective across the curriculum and impact more courses, Thus, the idea of “A Sustainability in Education Certification” was born and will be proposed as a Phase II grant proposal. As part of this certification, the graphic below was designed:



Goal #5: Assessment and Evaluation

- An outside evaluator, Marty Goldstein, was contracted to assess progress throughout the grant period. The assessment plan included both formative and summative measures. A pre/post test survey instrument was developed for student input as well as an advisory board survey for industrial input.
- Advisory board assessment survey indicated that 100% of the respondents were satisfied that the KIET group met the goals of the project and that the IME540 course learning objectives aligned with industry needs and that they were being met. Through the formal survey, advisory board members provided helpful insights and expressed interest in attending additional advisory board meetings. Complete survey results are shown in Part 2.
- Pre-course knowledge survey compared to post course knowledge survey shows a significant increase in self-assessed knowledge of environmental topics as a result of IME540. On a scale of 1 – 4 (1=very little knowledge and 4=very familiar) students self-reported average knowledge started the class at 1.5 and doubled by the time of completion with an average score of 3.6. Complete survey results are shown in Part 3.
- Individual module assessments by students and faculty have resulted in an understanding of the strengths, areas for improvement, and insights learned from each module. During the first offering of IME540 assessment information was gathered and compiled weekly by all KIET faculty for the purpose of improvement during future offerings. Complete assessment information is given in Part 4.

Goal #6: Dissemination

- The outside evaluator, Marty Goldstein, was also contracted to develop a project website for dissemination of project information. We also complied with the grant proposal to make links through Merlot for dissemination. The project website can be found at <http://green.kettering.edu>.
- Presentation of findings on campus at Kettering through professional organizations including Institute of Industrial Engineers (IIE), Society of Women Engineers (SWE), Mechanical Engineering (ME) Department Advisory Board, and GEO student group.

- Presentation of findings through national conference presentations including American Society of Engineering Education (ASEE) in 2006, 2007 and 2008, IIE in 2006, Course, Curriculum and Laboratory Improvement Principal Investigators (CCLI-PI) in 2008 and American Chemical Society in 2008 .
- A final workshop was presented at the ASEE Annual Conference in Pittsburgh, PA in June 2008 with an enrollment of 17 people.
- CD containing all course materials was made available to workshop participants, website visitors and others expressing an interest in the project.

Part 2 - IME-540 Environmentally Conscious Design and Manufacturing KIET Follow-up Advisory Board Survey Results

Your Name (Optional): Six (6) Advisory Board Members Responded

The KIET members would like to start out by thanking you for taking time out of your schedule to attend the Advisory Board meeting. All of your input and feedback from all of these meetings has helped to create a very comprehensive and innovative ecologically based curriculum.

Survey Topic Areas: 1) ABET Program Course Outcomes, 2) The Overall Goal of the NSF Grant, 3) The Course Learning Objectives, and 4) Course Materials and Delivery Methods

1) ABET Program Outcomes covered in this course:

- F. An understanding of professional and ethical responsibility
- H. The broad education necessary to understand the impact of engineering solutions in a global and societal context
- M. Describe, model, and measure current processes and systems and identify areas of improvement

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
This course has enhanced an understanding of professional and ethical responsibility. (F)	4	2			
This course has enhanced the understanding of the impact of engineering solutions in a global and societal context. (H)	4	2			
This course has allowed for the students to describe, model, and measure current process and systems and identify areas of improvement. (M)	3	3			
I would suggest these enhancements: -I found the approach innovative and it is clearly of interest to students and faculty at Kettering (and probably else where). Given Kettering’s focus and history, this is an excellent approach to increasing students’ interest in STEM. -Have more speakers from industry to discuss cases related to their specific industry. -It might prove useful to look at these three outcomes and the six course learning objectives to see if they can be adapted for individual use in other university courses. Our experience is that many staff “select out” a portion of courses such as this – when they are looking for real-life application of theoretical or academic concepts. -Discern some of the short term vs. long term dilemmas. Develop metrics for ethical short/long term decision making.					

2) The Goal of the NSF Grant:

The primary goal of this project was to develop a course that provided undergraduate/graduate engineering, science and management students with the skills needed to critically examine environmental issues in product design and manufacturing, and to arrive at viable solutions to these problems. Other goals include adaptation of innovative materials and pedagogical approaches into the course; integration of the course into the Kettering University curriculum; incorporation of corporate and academic input into the project; and assessment, evaluation and dissemination of project outcomes.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
This Goal statement accurately reflects the goals achieved through this course.	3	3			
I would suggest these enhancements: -The dissemination so far has been good, keep it up if possible even after the grant period ends! -I would suggest adding the words “sustainable” into some of the verbiage since that is the goal of how we want the students to thing at their work environments. -This is an excellent portrayal of a worth while goal. The goal which is stated at the end, that of dissemination, should prove to be the most important – to allow other staff at other institutions to use these materials and approaches to learning. -Keep making it as practical and real as possible, Good Start.					

3) The Course Learning Objectives

This course has met the following Course Learning Objectives:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provide a critical analysis of the historical, social, legal and ethical issues underlying the environmental impact of goods and services. (F,H)	5	1			
Evaluate life cycle analyses of products and/or processes and propose strategies for addressing environmental impact while still meeting design and economic requirements. (M)	4	2			
Conduct a material selection with a goal of reducing the environmental impact of a product and/or process while simultaneously reducing material costs. (M)	4	2			
Use appropriate tools to evaluate the environmental impact of a manufacturing process and recommend actions for reducing this impact and minimize production costs.(F,M)	4	2			
Propose design changes to a product to enhance recycling, reuse and/or remanufacturing capability with consideration of the economics of these activities.(F)	4	2			
Identify and apply best practices in promoting the environment in a corporate setting.. (H)	5	1			
I believe the topic of Green Chemistry should be integrated into IME540.	2	2	2		
<p>I would suggest these enhancements:</p> <ul style="list-style-type: none"> -About Green Chemistry -> the topic is appropriate but if too much is put into one course, the course will have breadth but no depth. I think depth is important so this issue must be weighed. -Green Chemistry is emerging to be one of the next by issues, there are initiatives underway in several states, CA most notably and Michigan. -The continued use and expansion of technology based learning approaches – and yearly review of the content to make sure it is accurate and complete. -Keep making them as practical and real as possible. 					

4) Course Material and Delivery Methods

- What do you think about the overall “quality” of the materials that were made available on the web site <http://green.kettering.edu> ?

 - Very high. I’ve recommended them to others.
 - Quality of materials was very good. Challenge of course is keeping things updated in the rapidly changing world.
 - Great!
 - The challenge will be to keep the high quality materials up-to-date deleting older materials which may become irrelevant and replacing them with more current concepts.
 - Very well organized and clear.
 - Excellent. This is a well-designed course and initiative. The faculty appear dedicated and enthusiastic. A module program.
- Are you interested and willing to attend future Advisory Board meetings?

 - All 6 – Said Yes
- Additional things to consider:

 - The only thing I would recommend is to integrate some ongoing assessments into the course that can lead to continual improvement and be used to continually monitor the course’s success at contributing to the intended learning outcomes.
 - How adapt for graduate level course and include more formal LCS procedures
 - Since the course is team taught by several faculty in their areas of expertise, it might be worthwhile to consider what might happen if one or more leaves the university. Could another faculty member easily and successfully take over a portion of the course? What is the level of knowledge (and interest) necessary to teach a segment of the course?

Part 3 – Pre-Post Test Student Survey Results

1 - Very Little 2 - Somewhat Familiar 3 - Familiar 4 - Very Familiar

		Pre avg	Post avg	Pre avg	Post avg
Module 1 Technology, the environment and industrial ecology					
a.	The history of the environmental impacts of industry.	2.2	3.4		
b.	The history of the social/ethical impacts of industry.	2.0	3.4		
c.	Environmental Ethics - moral and ethical dimensions of our interaction with the natural environment.	2.0	3.4		
d.	The meaning of terms like "the tragedy of the commons", "social responsibility", and "sustainability".	1.6	3.6		
e.	The meaning of "industrial ecology" or "green engineering/design".	2.0	3.6		
f.	How to assess the basic environmental and social impacts of everyday products -- i.e. the basic categories by which products are broken down into components to assess their environmental and social impacts.	1.6	3.6		
g.	Specific knowledge of the full range of environmental and social impacts of one article of clothing or everyday object that most people use.	1.4	3.6		
h.	The social, historical, and environmental impacts of textile production, specifically cotton cloth (t-shirts).	1.6	3.6	1.8	3.5
Module 2 Life cycle concepts and assessment					
a.	Life cycle stages	2.0	3.6		
b.	Life cycle assessment (LCA); approach and current challenges	1.4	3.4		
c.	Alternative approaches to LCA	1.2	3.6	1.5	3.5
Module 3 Material selection					
a.	Life Cycle impact of materials (i.e. plastics and metals)	2.0	3.6		
b.	Weighted Property Index method	1.0	3.6		
c.	Saaty's Scale for Pair-Wise comparison of materials	1.0	3.4		
d.	Performance Indices as applies to selection of materials	1.4	3.8		
e.	Cambridge Engineering Selector software (CES)	1.0	3.2		
f.	Exchange Value functions	1.2	3.4	1.3	3.5
Module 4 Process Design Issues					
a.	Process flow: inputs, outputs and wastes	1.8	3.6		
b.	Material and energy balances	1.4	3.6		
c.	Environmental impact minimization	1.8	3.6		
d.	Product delivery	1.4	3.4	1.6	3.6
Module 5 End-of-use strategies					
a.	Eliminate, reduce and re-use	2.0	3.8		
b.	Remanufacturing	1.6	3.2		
c.	Design for recycling and recycling processes	1.6	3.6		
d.	Workings of a landfill	1.4	4.0	1.7	3.7
Module 6 Environmentally responsible management					
a.	Economic and regulatory approaches to environmental control such as "cap and trade"	1.2	4.0		
b.	Identifying and managing competing interests in economic and environmental sustainability	1.6	3.6		
c.	Environmental management systems including ISO 14000	1.0	3.2		
d.	Green supply chains	1.0	3.4		
e.	Total (or life cycle) cost accounting	1.2	3.4		
f.	Developing environmentally responsible organizational cultures	1.6	3.8	1.3	3.6

Part 4 – Formative Faculty Assessment Results

The following assessment information was gathered and compiled at the weekly Tuesday lunch attended by all KIET faculty following the initial IME540 class period in Winter 2007. It was updated continuously as we learned and grew together during the term.

Assessment of IME540 Overall

Strengths

1. Students seemed to feel comfortable with the six faculty members
2. Intellectual environment of classroom is great for faculty (and hopefully for students)
3. Usually we tend to be critical but this class is positive
4. Personality of team is critical and this is the right team
5. This is fun and makes us feel good about working

Areas for Improvement

1. Syllabus should have used the term “evaluation” rather than assessment for grades
2. Instructor evaluation location is expected to follow standard separate survey in blackboard. The students didn’t know to look within the modules.
3. Need attendance policy. Some ideas: (1) Possibly have a participation grade tied to attendance. (2) Lose x% for unexcused absence. (3) Must attend all classes - loss of 2percent + any missed evaluation opportunities unless pre-excused. (4) If miss excessive class, take comprehensive final exam or drop.
4. Participation grade for attendance would be helpful
5. Instructor should call faculty (or students) to order when too many people are having separate conversations

Insights

1. It’s going to work out just fine with only six students
2. Students have a diverse background
3. For future team-taught courses, team needs to be selected very carefully
4. Need common format for lecture note-taking for continuity between modules
5. Final - each module has one question for final
6. Next time - all student presentations should be related to same product
7. Final: I would like to see one product assigned to each student and questions arise off that product. As for grading: Students should deposit the assignment in blackboard - that way we all have access to it and can grade our parts. We should divide up the points evenly between each module just like the class.

Assessment of IME540 Module 1

Strengths

1. Ben was energetic
2. Ben was passionate about topic
3. Ben did a good job of tying old to new with history
4. Props were great – bright green binder and organically made t-shirts
5. student presentations went well
6. We learned a lot from student presentations and they gave us ideas for our future modules
7. Students were great at fielding questions
8. Presentation format is good and allows students to get involved quickly

Areas for Improvement

1. Maybe too much history. The history facts need to be more connected to the environment to push our story forward.
2. Should have printed powerpoint slides on paper so students could take notes

Insights

1. Need to find products that are simple and yet complex enough for life cycle analysis in module 2
2. We should always allow students to pick their choice of products so they have some personal interest
3. Need more depth in student presentations – may be able to pick up same products in later modules

4. Grading rubric was purposely given only to students and not to other faculty so students didn't feel judged by all 6 faculty
5. Grading is difficult with an open ended project
6. First evaluation should be most difficult so students will feel challenged

Assessment of IME540 Module 2

Strengths

1. LCA points to use and disposal as having the largest impact on the environment. This is a natural lead-in to the end of life module.
2. Craig is a good communicator
3. Lots of examples of LCA with differing approaches showed complexity of topic
4. Good interaction during first session on water and global warming.
5. Excellent slides – very detailed
6. Software was interactive and engaged students
7. Students applying previous knowledge from course suggests that our modules are building off each other

Areas for Improvement

1. Topic needs to flow better through reorganization of notes.
2. Have students use software on 2nd day rather than 3rd day
3. Needs to be more interactive
4. Idea – provide a hands-on experience using an easy approach and then follow with more complexity
5. Detailed slides should be printed out larger. Some words were too small to read when printed 6 per page

Insights

1. Very complex topic is difficult to flow
2. An elementary approach to software would be helpful
3. Steelcase conference attended by Ben in 2005 had an eco-indicator session that gave results within 20 minutes
4. Mass energy flow will be covered again in Module 4
5. Great software (if can find - demo not available anymore)

Assessment of IME540 Module 3

Strengths

1. Jen is natural interactive instructor
2. feels like a 1-1 class
3. good job handling engineering mat'l
4. Good idea to bring in current events - brings topic to the world today
5. students were engaged the whole time
6. Overall great presentations
7. Energetic, nice to listen to
8. Like the performance criteria

Improvements

1. students didn't seem to have put effort into pre-reading and current event gathering - try sending email reminder to students
2. need larger print on handouts - 4 per page landscape seems to be larger
3. add eco-indicator score to matrix
4. “Big picture”
5. Performance indices before decision optimization
6. Have presentation in third day

Insights

1. Jen would sometimes like to be more formal
2. idea- online bb quiz before class so everyone does reading

3. A little awkward to present material developed by someone else - Trevor has different way of thinking from Jen
4. Current events good idea

Assessment of IME540 Module 4

Strengths

1. Industry rep makes the importance of topic real
2. Jalonne interacts easily
3. Amount of material and pace was good
4. Students were engaged
5. Appreciated real data
6. Appeals to a variety of students background
7. Jalonne had a nice, laid back approach
8. Good integration of class and coop experience
9. Assignment applied to Kettering University campus so everyone could relate
10. Hands-on dunnage example work well, students related to dunnage

Improvements

1. Write bigger
2. Need to be more challenging - data was obvious - students may be bored
3. Assignment should be given in advance and tied together with more guidelines for completion
4. Have students gather data themselves and then compare to instructors – this will help to engage them into a deeper analysis and understanding
5. Should go deeper into analysis with new ideas. Answer the question “what is unique to GEMA?”
6. Make appt w facilities personnel early so students can meet as a group
7. Give students during first class overview of structure and grade weighting and breakdown
8. One presentation on third day integrating everything rather than two separate

Insights

1. Instructor should call faculty (or students) to order when too many people are having separate conversations
2. Students were more engaged because of their coop experience
3. Thought the students should have offered more insights from their coop experience, particularly in the area of regulations
4. Two sets of small presentations broke up the class periods but didn't allow depth
5. Could integrate lecture research/discussion into students coop experience
6. Need more information about regulations - landmark acts

Assessment of IME540 Green Chemistry

Strength

1. Hands on lab experiment
2. Active lecture style
3. Reaction time enabled talk time while waiting
4. Chemistry lab fun!

Improvement

1. Ideally we could make biofuel run a small motor
2. Calorimeter would allow test for energy of biofuel

Insights

1. Idea - spread out reactions to other class and integrate into other module
2. Case studies from Dow would be helpful
3. Wells to wheels analysis (Craig) takes back to primary source
4. Glycerin as a by product has a use- life cycle thinking - what can be done with byproduct?
5. Students didn't take notes

6. Need some evaluation mechanism

Assessment of IME540 Module 5

Strength

1. Field trip to landfill was good experiential learning
2. Module was well organized and structured
3. New information was presented
4. Assignment was well-done
5. Students put good time and thought into presentations – it helped that students had more time due to the holiday
6. Students seemed to like faculty interaction and comments
7. Peer assessment of presentations was good

Improvement

1. Bring student BB questions to landfill for discussion
2. Need better rubric for BB w points for responding to others posting - need ongoing relationship rather than one night stand
3. Need to be specific about how to dress for landfill tour (old boots, warm coat, etc)
4. On first day, when error was found in lecture handout, should have had students take notes rather than take class time to go to copy center to correct mistake
5. Could get more content out of landfill tour by analyzing process data from People's Generating
6. Could compare electricity generating station to a coal plant for measures of efficiency

Insights

1. Have students develop a diagram of landfill process inputs and outputs as assignment - have students gather as much information as possible from tour
2. Content of module was sufficient
3. Idea to have students model the landfill before going, then go ask questions, then update model after visit based on answers to questions
4. What is the boundary of system?
5. Have students do SII for peer evaluation

Assessment of IME540 Module 6

Strength

1. Module was very clear and well-organized
2. Enjoyed business topics - not normal for engineers to take this kind of class
3. Good practical content - especially for engineers
4. Positive atmosphere in class –
5. Instructor kept pulse high and had good engagement with students
6. The atmosphere that you created was great. The students enjoyed the cap and trade game and it was a great exercise. Awesome student involvement.

Improvements

1. Article should have been out sooner to allow time to finish
2. Technology issue - difficult to have video stream using slow wireless tech
3. Laptop position sometimes blocked the view of students
4. Cap and trade game got shortchanged. One idea is to have pre-made spreadsheet to expedite the analysis
5. Would like to get to market driven prices
6. Need to get quiz done by first class
7. Bring Coffee every day ☺ (Comment related to Starbucks case study)

Insights

1. The quiz distribution ranged from 2.5 - 5
2. Need to force students to be prepared and do reading before class
3. Lead time on posting links needs to be evaluated
4. Evaluate readings for cost and effectiveness for learning and retaining info
5. I did not realize the Starbucks philosophy. Do other coffee companies behave in the same manner?