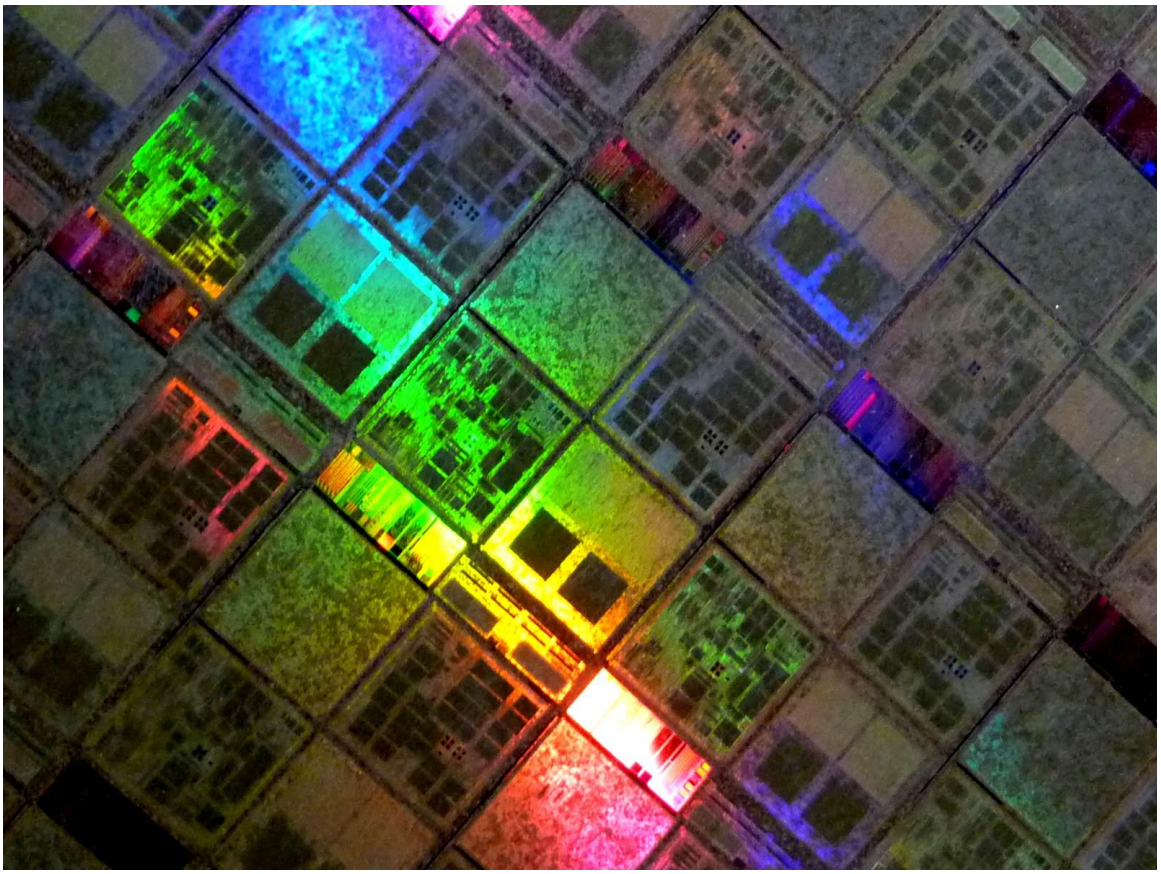
PROCEEDINGS OF THE 4TH SYMPOSIUM ON ENGINEERING AND LIBERAL EDUCATION



JUNE 3-4, 2011

UNION COLLEGE

SCHENECTADY, NEW YORK

Cover image: Detail of 300mm wafer produced at IBM's chip fab in East Fishkill, NY and presented to Union College in 2003 in recognition of Union's efforts to integrate engineering and the liberal arts. The wafer is on display in the Castrucci Gallery in the Peter Irving Wold Center at Union College.

Photograph by Doug Klein.

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NOTE: *The slide presentations and posters are available at the 2011 Symposium web site: http://www.union.edu/integration. If you are reading these Proceedings online, the titles of each presentation are hyperlinked to the relevant slides or poster.*

The URL for the 2012 Symposium is: http://ele.union.edu

Preface

This booklet represents the Proceedings of the 4th annual Symposium on Engineering and Liberal Education. The Symposium consisted of an outstanding collection of presentations, posters and panels covering the theoretical and the practical aspects of integrating engineering and liberal education. The program also included a panel from the "real world" to describe how integration pays off in practice.

We are especially pleased to acknowledge the sponsorship of IBM, and Dr. David Ferrucci, IBM Fellow, who led IBM's "Watson" project, as the Symposium's keynote speaker.

2011 also marked the inaugural i2iFI: Integrate to Innovate Faculty Institute. The Institute ran Saturday afternoon, and offered participants a choice of four workshops, each designed to enhance faculty skills in curricular integration and collaboration. An outline of the topics covered is included in these Proceedings

On behalf of the Program Committee, we thank you for your interest in the integration of engineering and liberal education and we hope to see you again in 2012.

Cherrice Traver and Doug Klein
Symposium co-Chairs

2011 Symposium co-chairs

Cherrice A. Traver, Dean of Engineering and David Falk and Elynor Rudnick-Falk Professor of Computer Engineering, Union College, Chair

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Part I: Keynote Address

Building Watson: An Overview of DeepQA for the Jeopardy! Challenge

David A. Ferrucci
IBM Fellow

ABSTRACT: Computer systems that can directly and accurately answer peoples' questions over a broad domain of human knowledge have been envisioned by scientists and writers since the advent of computers themselves. Open domain question answering holds tremendous promise for facilitating informed decision making over vast volumes of natural language content. Applications in business intelligence, healthcare, customer support, enterprise knowledge management, social computing, science and government would all benefit from deep language processing. The DeepQA project is aimed at exploring how advancing and integrating Natural Language Processing (NLP), Information Retrieval (IR), Machine Learning (ML), massively parallel computation and Knowledge Representation and Reasoning (KR&R) can greatly advance open-domain automatic Question Answering. An exciting proof-point in this challenge is to develop a computer system that can successfully compete against top human players at the Jeopardy! quiz show (www.jeopardy.com). Attaining champion-level performance Jeopardy! requires a computer system to rapidly and accurately answer rich open-domain questions, and to predict its own performance on any given category/question. The system must deliver high degrees of precision and confidence over a very broad range of knowledge and natural language content with a 3-second response time. To do this DeepQA evidences and evaluates many competing hypotheses. A key to success is automatically learning and combining accurate confidences across an array of complex algorithms and over different dimensions of evidence. Accurate confidences are needed to know when to "buzz in" against your competitors and how much to bet. High precision and accurate confidence computations are just as critical for providing real value in business settings where helping users focus on the right content sooner and with greater confidence can make all the difference. The need for speed and high precision demands a massively parallel computing platform capable of generating, evaluating and combing 1000's of hypotheses and their associated evidence. In this talk I will introduce the audience to the Jeopardy! Challenge and how we tackled it using DeepQA.

Dr. David Ferrucci is the lead researcher and Principal Investigator (PI) for the Watson/Jeopardy! project. He has been a Research Staff Member at IBM's T.J. Watson's Research Center since 1995 where he heads up the Semantic Analysis and Integration department. Dr. Ferrucci focuses on technologies for automatically discovering valuable knowledge in natural language content and using it to enable better decision making.

As part of his research he led the team that developed UIMA. UIMA is a software framework and open standard widely used by industry and academia for collaboratively integrating, deploying and scaling advanced text and multi-modal (e.g., speech, video) analytics. As chief software architect for UIMA, Dr. Ferrucci led its design and chaired the UIMA standards committee at OASIS. The UIMA software framework is deployed in IBM products and has been contributed to Apache open-source to facilitate broader adoption and development.

In 2007, Dr. Ferrucci took on the Jeopardy! Challenge – tasked to create a computer system that can rival human champions at the game of Jeopardy!. As the PI for the exploratory research project dubbed DeepQA, he focused on advancing automatic, open-domain question answering using massively parallel evidence based hypothesis generation and evaluation. By building on UIMA, on key university collaborations and by taking bold research, engineering and management steps, he led his team to integrate and advance many search, NLP and semantic technologies to deliver results that have out-performed all expectations and have demonstrated world-class performance at a task previously thought insurmountable with the current state-of-the-art. Watson, the computer system built by Ferrucci's team is now competing with top Jeopardy! champions. Under his leadership they have already begun to demonstrate how DeepQA can make dramatic advances for intelligent decision support in areas including medicine, finance, publishing, government and law.

Dr. Ferrucci has been the Principal Investigator (PI) on several government-funded research programs on automatic question answering, intelligent systems and saleable text analytics. His team at IBM consists of 28 researchers and software engineers specializing in the areas of Natural Language Processing (NLP), Software Architecture, Information Retrieval, Machine Learning and Knowledge Representation and Reasoning (KR&R).

Dr. Ferrucci graduated from Manhattan College with a BS in Biology and from Rensselaer Polytechnic Institute in 1994 with a PhD in Computer Science specializing in knowledge representation and reasoning. He is published in the areas of AI, KR&R, NLP and automatic question-answering.

Part IIA: Presentations: Integration, Innovation, and Leadership

Creative Innovation: Tautology or Opportunity?

Diane Michelfelder, Macalester College

In educating engineering students to be productive and socially responsible engineering practitioners, building capacity for innovation has been identified as a very high priority. In this presentation, I am interested in exploring how the outcome of building capacity for innovation among engineers could be supported by questioning what seems to be a fairly obvious truth: namely, that the phrase "creative innovation" is a tautology. At first glance, such a claim may seem to be nonsensical. Creativity is often taken to be the mental "fire" or "juice" that undergirds innovation, understood in this context as a new, cost-efficient, marketable result that responsibly improves the conditions of life. From this perspective, the more novel the innovation, the more powerful the creative idea behind it, with particularly imaginative and creative thought leading to transformative innovations of the order associated with the NAE's Grand Challenges. While the above connection between creativity and innovation is well-pronounced within the realm of engineering, it is much less pronounced from the perspective of the liberal arts, where creativity and innovation tend to be divorced from one another. In the realm where creativity is arguably most closely tied to innovation, namely the arts, an original poem or a new musical composition would likely be described as an innovation only if it leads to the development of a new artistic form, and hence opportunity for future creativity. While the development of creative thinking is often thought of as an important goal of a liberal arts education, conversation within the liberal arts about innovation, particularly within the humanities, tends to be confined to discussion of innovative approaches to teaching, rather than to the importance of teaching students how to use creativity for the purposes of innovation. Why has creativity been emphasized and innovation downplayed in the context of a liberal education? While multiple answers could be given to this question, one might be found by looking to the philosophical underpinnings of liberal education. In this context, creative thinking can be seen as a way of responding to one of life's largest questions: the philosophical question: "Who am I?". So understood, creativity appears as a form of self-exploration that contributes to the formation of a meaningful narrative about who one is. The connection of creativity to the construction of meaningful self-narrative, I would like to suggest, is the element that makes the idea of "creative innovation" something more than a simple tautology. And, it is this dimension of creativity that is in large part missing from engineering thinking about and discourse about innovation. Here there is, I would like to think, an opportunity to be had. Future engineers might be able to be better innovators if their education included opportunities for them to become creative thinkers in the tradition of the liberal arts.

How Can I Know What to Innovate until I Know How I have Learned? – Integrating Learning and Innovating Processes in Situated Learning Environments

Peter Bacevice, DEGW North America

How you learn is how you innovate. The intellectually integrated university classroom that cultivates and nurtures the heterogeneous learning styles of today's students will impact the multiple paths to value creation of tomorrow's innovators. Learning and innovating are parallel actions that require a similar negotiation among the inherent tensions in the experiences we routinely face. These tensions manifest Likewise, these tensions manifest within business organizations and the ways in which they shape stability and adaptability as well as internal and external positioning. This proposed presentation discusses the similarities between learning and innovating and offers a

framework that links learning styles, value creation, and the unique pedagogical characteristics of different academic disciplines. The central premise is to present a theoretical framework that illustrates the relationship among academic disciplines, their pedagogies, differences in learning styles characteristics, and the ways in which learning styles coincide with differing forms of innovation. The relevance of this framework extends to the strategic integration of academic disciplines, especially the integration of engineering and liberal arts. The theoretical framework proposed here is rooted in two leading paradigms from both management and education scholarship. These paradigms are characterized by similar patterns of recognition and integration of experiential differences. The first paradigm - Experiential Learning Theory - posits that learning is an interaction between the person and the environment and that learning requires the resolution of conflicts among adaptations of the world. The second paradigm - the Competing Values Framework - posits that value is created through recognizing and reconciling among individual and organizational adaptations to the market. The similarities between these paradigms and its impact on student learning and innovation will be discussed.

Understanding Engineering Systems Futures: Using Scenario Analysis and Planning to Develop Engineering Systems Leadership

Darryl Farber, Pennsylvania State University

Scenario analysis and planning provides a way for engineering students to systematically integrate political, economic, and socio-cultural aspects of complex, large-scale engineering systems into their understanding of the operation and evolution of these systems. Engineering systems also called socio-technical systems are, for example, the transportation, communication, and energy system and the interconnections among these. Additionally, scenario analysis and planning enables consideration of how emerging technology may change the way engineering systems operate and change over time. This paper describes the development of an experimental engineering leadership course based upon scenario analysis and planning at Penn State University. The course serves as a capstone for the engineering leadership development minor and is geared for students in science and engineering. Leveraging the student's background in science and engineering, the course sought to deepen and broaden their analytical skills as well as develop their synthetic thinking ability by using systems thinking and scenario analysis and planning to explore how advances in technology may impact economic competitiveness, environmental sustainability, and global security. Developing in the students an intellectual dexterity and agility regarding how different perspectives and interpretations of science and technology, especially regarding risk and how risk is managed and communicated, along with the ability to communicate clearly in writing and verbally is an overarching goal. Through the practice of systems thinking and scenario analysis and planning students can learn to develop judgment and insight about the evolution of technology and its relationship to human cultures and global civilization. The course develops critical thinking skills, which include creative thinking, exploring alternatives, situational awareness, and synthesis and provide a foundation for strategic thinking - an essential quality of mind required for leadership.

Analysis of Engineering Capstone Design Student Reflective Memos: What Students Say and What They Don't Say

Mark Steiner, Cheng Hsu, Rich Alben, Lester Gerhardt, Junichi Kanai, RPI

Having students articulate and reflect upon their experience is a valuable and important way to reinforce an appreciation for lessons learned in the context of capstone design. Taken together with peer evaluations, end-of-semester student reflective memos can be an invaluable source of assessment information and provide guidance for continuous improvement of educational processes in line with ABET criteria and outcomes. However, concerns about the proper use of these reviews abound. Foremost is the qualitative and subjective nature of reflections and the challenges this presents to translating the reflections into recommendations for course improvements. Because reflective memos do not readily lend themselves to numerical analysis, they can be easily overlooked over time and the value they potentially represent lost. This paper provides an analysis of end-of-semester student reflective memos collected over five years from a capstone course based on real world multidisciplinary design experiences. Disciplinary participation included students from biomedical, computer systems, electrical, industrial and mechanical engineering. The analysis focuses on a study of what students express as relevant learning points. We have found students to be surprisingly frank about what they learned and where they thought their experience in the course fell short. Over time we have observed common themes that emerge among students concerning their ability to deal with project changes and team dynamics and have charted the resulting ebb and flow of enthusiasm and motivation over the course of a semester.

Part IIB: Integrative Programs

Bachelor of Arts in Engineering - A Proposal

Louis Bucciarelli, MIT

In an address to the annual meeting of the National Academy of Engineering in September, 1995, Charles Vest, then president of MIT, offered this thought re engineering education:

I think we have to de-emphasize narrow disciplinary approaches, particularly in our curricula and in the way we teach students to think. We need to pay more attention to the context in which engineering is practiced... This sounds simple, but we're finding it, at least at my institution, very challenging.

Why has it been so hard to change our educational priorities? (I assume the need for change is a shared sentiment of most faculty of engineering). My claim is that the instrumental focus of our traditional engineering curriculum, with its almost sole focus on the solution of well-posed problems that admit of but a single response, works against significant change. It discourages any critical reflection upon ends or "the context in which engineering is practiced". What is needed is a new way of envisioning engineering education, a way that sees study in the humanities, the arts, and the social sciences, not as means aimed at developing the students "human interaction skills" in courses added on to meet the "needs of the workplace", but as an essential ingredient of the education of a fully professional, intellectually mature, and reflective citizen.

My proposal is to build on the content and forms of instruction in the traditional engineering program but dramatically transform both content and forms to meet new ends, new educational objectives - those associated with a liberal education. Drawing upon my own experience in attempting innovation of this kind, I will describe how this transformation - in engineering science, in laboratories, in design courses - might be accomplished.

Flying in the Face of Adversity: The Struggle to Commingle Liberal Arts with Engineering at a Public Polytechnic

Lizabeth Schlemer, David Gillette, Cal Poly, San Luis Obispo

Even though many academics see benefits in infusing engineering education with aspects of the liberal arts, and recognize a clear need for exposing liberal arts students to engineering practices and ideals, effectively combining these two areas of study in the first decade of the 21st century still involves re-fighting many of the ideological battles from the first decade of the 20th century. Our paper reviews the activities at our institution over the past ten years as Cal Poly has attempted to combine the studies of the liberal arts with engineering. Although our university is not fundamentally different from other similar-sized institutions, there are particular challenges we face when attempting new forms of curricular redesign that conflict with our polytechnic mission, the political and economic climates of California, and the university's historical attachment to traditional definitions of disciplinary difference. We review successful and failed examples of initiatives and proposals that challenged the status quo. We discuss specifics from Cal Poly, but our paper is also grounded in recent research on the differences between the epistemologies of engineering and liberal arts. When examining the larger context of this issue, we consider a number of the conflicting disciplinary philosophies that make the effective combining of liberal arts with engineering such a difficult nut to crack. The ultimate goal of the paper is to initiate an open and honest conversation about the practical difficulties in overcoming disciplinary separation with hopes of generating discussion about possible solutions at similar institutions.

Integrating Multiple Perspectives in Engineering Education

Sharad Malik, H. Vincent Poor, Princeton University

The Keller Center, founded at Princeton in 2005, trains future leaders through an emphasis on the transformative role of engineering in society. It does this in part through the development of courses and programs that emphasize the societal aspects of engineering. These are specifically designed to attract both engineers and non-engineers, thus providing a collaborative environment in which students are exposed to multiple perspectives, both engineering and societal, in an integrative way. A collaborative course, Technology and Society, has been developed by faculty in engineering, sociology, policy and history of science and technology, to provide students with a set of intellectual tools to help organize the multiple-perspective treatment of issues at the intersection of technology and society. This course also serves as the introductory course for a new Certificate Program in Information Technology and Society that provides students a mechanism for students to engage with an interdisciplinary topic through a focused set of courses and research projects. The Center further seeks to make engineering an integral part of the liberal arts curriculum through courses that emphasize the foundational aspects of the engineering discipline in a societal context and that are accessible to a broad student base. An example of such a course is The Wireless Revolution, which covers the technical basis for wireless communication and combines it with the many political, societal and economic issues that relate to this technology that touches more than half of the world's population. In this talk I will share our experiences in developing and teaching these courses to students from a broad range of departments on campus.

Rensselaer's Programs in Design and Innovation: Curricular and Pedagogical Dimensions of E&LE Integration

Dean Nieusma, RPI

This paper presents Rensselaer's Programs in Design and Innovation (PDI) as a model initiative for integrating engineering and liberal arts education to foster innovation and entrepreneurship. PDI offers a set of tightly integrated, studio-based dual-major options spanning engineering, liberal arts, entrepreneurship, and creative design. A liberal-arts-based BS in Design, Innovation, and Society serves as the common degree for all PDI students, most of whom dual major in engineering, management, or graphic design. For engineering students, the PDI studio sequence entails seven studios, each with a different emphasis but all integrating technical and social analysis with creative design using a problem-based learning approach. Studios are taught by faculty representing different domains, and some of the studios are team taught. In addition to reviewing PDI's curricular structure (and how we cover everything within the constraints of an 8-semester, ABET-accredited program), the paper will describe two pedagogical approaches for integrating liberal arts content. It will review two design studio courses (both taught by the author) — one a sophomore-level introduction to user-centered design and another junior-level introduction to idea dissemination and entrepreneurship. At the highest level, learning outcomes of PDI studios revolve around the ability to utilize liberal arts approaches and insights to conceptualize, refine, advocate, and communicate innovative products, services, and systems. The paper will conclude by reviewing some of the challenges to integration and assessment faced by the program.

Part IIC: Oh! The Humanity

Bridging the Gap Between Engineers and Society: Learning to Listen

Yanna Lambrinidou, Marc Edwards, Virginia Tech

Although engineers and scientists strive to improve the quality of life and sustainability of societies, the effectiveness and integrity of their labors will be compromised if their methods do not hold the public welfare paramount. Engineers in active communication with their ultimate client, the too often "unseen" and "silent" public, enjoy access to a wealth of information that is essential to informed decision-making and are deserving of the public trust. In contrast, we argue that engineers who are alienated from their public clients are more vulnerable to self-interest, self-delusion, and institutional pressures that contribute to unethical conduct and harmful decisions. Recent cases of community exposures to toxic materials, investigated by the United States Congress, have revealed a dangerous and perhaps growing disconnect between engineers and scientists, and the publics they are supposed to serve. We believe that unless engineering education helps students bridge this gap, engineers will remain vulnerable to overlooking empirical data, of both a technical and non-technical nature, that can greatly enhance their work. "Learning to Listen: An Empirical Approach to Engineering Ethics Education" is an approach that we are taking to connect engineers to their "unseen" and "silent" client, and to ensure that the public's needs, experiences, and knowledge are always given due consideration. The course is based on the premise that "good ethics depends upon good facts," and that a critical source of these "facts" can be the public. "Learning to Listen" teaches ethics through moral theory, codes of ethics, and key ethical concepts, but most importantly through grounded case studies and in-depth interviews of members of the public -- professionals and non-professionals -- involved in cases of environmental contamination. The presentation will discuss our initial successes and challenges with this empirical approach to engineering education.

What Does It Mean to Be Human?

George Catalano, State University of New York at Binghamton

An interdisciplinary course has been developed and offered which explores what it means to be human. The course is at the senior level and required for all bioengineering majors at Binghamton University and an available humanities elective for all other engineering majors as well as being open to the entire university. Bringing together advances from the frontiers of genetic research, nanotechnology and robotics, the course nurtures a contemplation what is or may soon be possible due to rapidly accelerating technology. Current literature suggests that there is no boundary to human ambition or desire or to what our very inventions may make possible. Microscopic nanobots may soon be consuming the world and children may soon be born so genetically enhanced that "they will never be able to believe that they reach for the stars as pianists or painters or long-distance runners because there is something unique in them that has a passion to try." (McKibben, 2010) According to some researchers, the day of the robotically striving human is already here. Ultimately this leads to a consideration of what makes a human being apart from other beings and whether or not pain-free, all-but-immortal, genetically enhanced semi-robot but will lead to a more fulfilled life or one of deep unsatisfaction. Students are confronted with these issues in and asked to struggle with their own fears and vision for the future.

Tools to Craft Ethical Behavior

Martin High, Scott Gelfand, Steve Harrist, Oklahoma State University

Engineering educators provide students a wide variety of tools and skills: mathematics, chemistry, physics, computer programming, and discipline specific knowledge. All of these tools are designed to be multipurpose and adaptable to whatever problem the student will face in professional life. However, one area in which our students tend to be underprepared and tend to be lacking in analogous "tools" to solve problems is in ethics. Ethics is typically taught by showing students case study after case study that exemplify unethical behavior. Standard ethics classes neglect the topic of moral psychology. Specifically, these classes do not teach students why people act unethically, and they do not provide students with strategies that they can use in order to increase the likelihood that they will act in accord with their own ethical commitments and/or the ethical codes of their professions. We are designing a class that will expose students to video clips containing re-enactments of published empirical studies that demonstrate why people act unethically. After a discussion of each clip, each individual student will be guided through a two-part exercise. The first part, developing a Personal Inventory Report, will help the student engage in reflection in order to determine what sorts of situations the student might find ethically challenging. The student will then develop a personal plan (Adaptive-Strategies Report) addressing what strategies they might use in order to increase the likelihood that they will act ethically in challenging situations (that is, the situations arrived at while developing the Personal Inventory Report). The Adaptive Strategies Report will help the student: 1) recognize when an ethically challenging situation; and 2) act ethically in ethically challenging situations (that is, apply the strategies developed for the Adaptive-Strategies.

Part IID: Integrated Courses

A First-year Learning Community that Integrates Science, Engineering and the Traditional Liberal Arts

Ari Epstein, Samuel Bowring, Charles Harvey, MIT

Terrascope is a learning community in which first-year MIT students work in groups to develop solutions to complex, multidisciplinary environmental/Earth-system problems, and to communicate with the public about the problems and solutions. Because of the nature of the problems, and the comprehensive approach students are encouraged to take, the students' work incorporates knowledge and methods from a wide variety of disciplines within science, engineering and the traditional liberal arts. This integrated approach inspires students' creativity and helps them achieve truly innovative results, while preparing them to take leadership roles in creating and managing multidisciplinary teams to tackle other large problems, at MIT and beyond. We present details of the program's academic and social components, show and discuss some student teams' work, and describe ways in which the integrative, student-driven nature of the program contributes to its success.

Engineering & Liberal Arts Entrepreneurship Seminar

Hal Fried, Union College

This course is an exciting, interdisciplinary, socially responsible, entrepreneurial experience for students at Union College constructed from the following building blocks:

- Union College is a liberal arts institution with engineering.

- Every engineering student is required to undertake a senior project.

- Union College is situated in the Capital Region of New York State, which is aggressively pursuing a high tech development strategy (Tech Valley).

- The College is committed to innovation and entrepreneurship.

An economics professor and a mechanical engineering professor teach a course to develop business/marketing plans for socially responsible senior projects in engineering that explore the potential for commercialization. Interdisciplinary E-teams are organized around each senior project. Teams are composed of an Engineer, an Economics major, a Humanities major (English, Modern Languages, Philosophy, Classics) and an Arts major, for example. In order to be successful, the engineer has to communicate the value of his/her innovation to liberal arts students; liberal arts students have to communicate the marketing and business strategies to the engineer. The course is about interdisciplinary communication, teamwork, social responsibility, entrepreneurship and commercialization.

The learning objectives of the course are:

- To motivate, excite and inspire engineers and liberal arts students to pursue socially productive entrepreneurial ideas, maybe even to start a company.

- To introduce students to high-productivity, interdisciplinary teams composed of engineers, artists, economists and humanists.

- To foster cross-disciplinary communication and respect.

Enhancing Student Engagement and Professional Identification and Development through Entrepreneurial Simulation as Applied to a First Year IT & Web Science Course

Atsushi Akera, Rensselaer Polytechnic Institute

"ITEC-1220 Information Technology and Society" is a liberal-education based core seminar required of all first year Information Technology majors. The course is designed to secure student engagement and identification with the IT

Profession as specifically distinct from a more technical course of study in computer science. While our IT and Web Science Program maintains a rigorous technical core (enhanced through the recent addition of its "web science" component), the presumption with regards to both IT and web science is that students must learn to design information systems based on a studied understanding of the application domains and social environments in which their solutions must function. The work we do in this course also contributes directly to a student's innovative and entrepreneurial capacity, specifically as based on the model of Engineering and Liberal Arts integration. This course pursues this significant learning outcome through the pedagogic strategy of large-scale social-entrepreneurial simulation. Based on a the general model of educational simulation, and drawing as well on the notion of social-entrepreneurship, the course begins by asking selected students to become voluntary "CEOs" of a dot-com (or dot-org) start-up. To anchor the simulation, the course's lead instructor and TAs play the part of a fictitious philanthropic foundation devoted to social advocacy through the development of new IT solutions. The foundation issues regular (weekly or bi-weekly) requests for proposals, to which the student teams are required to respond. Through this structure, the course is designed to direct the student's attention to the "problem formulation" phase of innovation and engineering problem solving. Given that the course is offered during the first year, we assume no technical knowledge on the part of the students. Thus, rather than asking them to implement a solution, the course aims to maintain and develop a student's capacity to envision innovative solutions to complex, sociotechnical problems. It also familiarizes them with the strong entrepreneurial model that exists within the field of information technology. The course also serves the pedagogic goals of student engagement, team-based learning, collaborative problems solving, and professional development and identification.

Part IIE: Technological Literacy

Overview of Science, Engineering, and Technology

Dan Dimitriu, Jerry O'Connor, San Antonio College

The presentation will propose the development of a two credit-hour freshman core course that will provide students with an understanding of the role science, engineering, and technology play in today's society. It should be designed as a core curriculum course for students entering higher education regardless of their field of study and provide them with an overview of the nature and process of science and careers in engineering and to raise their awareness of how pervasive and important is technology in our lives. In an increasingly technical world it should be inconceivable that somebody with a college degree does not have any core technical exposure. At the same time it will help the students who are unsure if they want to pursue study in engineering or science and want to explore those fields before deciding.

Engineering Minors as a Means of Integrating Engineering and Liberal Arts

John Krupczak, Hope College, Mani Mina, Iowa State U., Robert Gustafson, Ohio State U., James Young, Rice University

While the integration of engineering concepts into a liberal arts education has long been promoted as desirable, the means to accomplish this integration have been limited. This poster will describe work sponsored by the National Science Foundation that aims to develop minors or certificates to be offered by engineering departments as an approach to developing technological competence in non-engineers. Minors or certificates provide a recognized credential deemed attractive by many students. A collaboration between w State University, x State University, y College, and z University is developing concepts and resources to support model engineering minors or certificates which can be adopted efficiently and widely within American higher education. This work is developing a set of Technological Literacy Outcomes for such a minor. These outcomes are similar in concept to the ABET a-k outcomes that are used for engineering degrees, but are broader in scope and focus on developing broadly technologically literate and empowered citizens. A standard set of outcomes rather than a prescribed series of courses, will allow flexibility for each institution to develop minors or certificates that are best suited to its local conditions. The poster will include examples of courses offered by engineering departments for non-engineering students and descriptions of engineering minor programs from a range of institutions. Some preliminary results from surveys of non-engineering students regarding factors influencing potential interest in engineering minors or certificates will also be presented.

Engineering as a Second Language

Jenn Rossmann, Lafayette College

When introducing liberal arts students to the methods, history, and values of engineering, what strategies are most effective? How can courses and extracurricular opportunities help students achieve both literacy and fluency in "Engineering as a Second Language?" Panelists will discuss courses (which address ESL vocabulary and syntax), project experiences such as EWB (which are more immersive experiences), and curricular design for programs (like Engineering Studies at Lafayette) designed to produce multilingual graduates.

Part IIF: History and Engineering

History and Engineering

Wade Robison, Rochester Institute of Technology

We train students of engineering so that it becomes second nature to think of design problems quantitatively, but quantitative considerations will not determine a solution. So we expect engineers to be imaginative, with a sense of all that is possible within the constraints set by quantitative considerations. These two ways of looking at a design problem are obviously compatible: we would otherwise not have wonderful solutions to design problems. But they can be difficult for individuals to obtain. What can help engineers marry imagination and a quantitative mental stance is to bring to design problems an historical sensibility and research skills. At a minimum an engineer must ask, "How did this problem arise?" Without an understanding of the original difficulty, we cannot even know that the stated design problem is correct. But it will also help the engineer to know what sorts of solutions have previously been suggested for that problem or similar ones. We then mine not only our own minds, but the minds of those who came before us -- a far richer trove of material than any single one of us is likely to have. And it will help to know what habits of use individuals are going to bring to a new solution that they have inherited from older solutions.

That will constrain in some ways whatever new solution is proposed since, among other things, no solution is acceptable that will guarantee that those using it will be harmed because they will bring past patterns of use to the new artifact. So engineers need to think like an historian when they approach design problems, with the sensibility and research skills historians are trained to use and teach.

History and Engineering Combined to Learn About Water-Powered Gristmills

David Del Testa, Thomas Rich, Bucknell University

At Bucknell, two faculty members with a common interest in water-powered gristmills have found ways to combine their knowledge and interests to pursue both teaching and research activities. The main focus is on the mills of Union County, Pennsylvania where Bucknell is located. For the past two years they have conducted research into the history of these mills. They have identified over 20 gristmills; some date back to the late 1700's. These mills have had a significant impact upon the county, and there are a number of interesting questions to pursue from both the historical and engineering points of view. The answers to these and other questions will serve as a basis for a book slated to be published by the Union County Historical Society as part of their Heritage series. While conducting their collaborative research, David Del Testa and Tom Rich decided to offer a Bucknell, integrated perspectives course on the topic. During the spring 2011 semester they are teaching HIST 275 - Mills, Milling and Local History to six students ranging from sophomores to seniors; liberal arts to engineering. This course uses local water-powered mills, the history surrounding them, and their larger social, economic, and cultural impact to explore questions of consequence of human interaction with the environment. When students leave the course, they should have a strong sense of the local region's environmental history and a strong sense of how to begin to analyze similar histories in other places. The current joint efforts to learn about water-powered gristmills demonstrate the power of integrating engineering and the liberal arts for the intellectual growth of both faculty and students.

Engineering in Ancient Rome

Stacie Raucci, Tom Jewell, Union College

The presentation will illustrate the cooperation between an engineering and a classics professor to produce an engineering module for an advanced Latin language class entitled Reading Rome: Textual Approaches to the City. The class was first offered in spring 2010. The objective of the course was to increase student skills in reading the Latin language while considering a particular theme: the city of Rome as palimpsest. Through an examination of sites-in-ink, we considered how and why the ancient city was constructed, as well as examined Roman identity and power relations. The main part of the course was handled by a faculty member in the department of Classics. In a successful experiment, an engineer performed a one-week module on Roman water systems, discussing topics such as Roman engineering in general, Roman arches, the inverted siphon, Roman aqueducts, and Roman baths.

Part III: Integration in Action: Views from the Outside

Sarah Bittleman

Sarah Bittleman is a Senior Advisor to USDA Secretary Tom Vilsack specializing in all energy issues, as well as Environmental Protection Agency issues. Bittleman previously worked for the Department of the Interior, the U.S. Senate and the House of Representatives on a range of policy and strategic development issues involving agriculture, energy, natural resources and climate change. She holds a Master of Public Administration from East Carolina University, a Juris Doctorate from Tulane University of Law School and a BA in Political Science from Union College in New York.

Stephen MacMinn

Dr. Steve MacMinn is currently the Chief Technology Officer at GlobalSpec, an online marketplace for targeted search, information services and e-publishing connecting buyers and suppliers in industry. Dr. MacMinn received his B.S. in Electrical Engineering from Lehigh University, and M.S. and Ph.D. degrees in Electrical Engineering from Cornell University. Dr. MacMinn holds thirteen U.S. and international patents. He is the author or co-author of eleven publications.

Karen St. Germain

Dr. Karen St. Germain works at the Pentagon for the Office of the Secretary of Defense, in the Space and Intelligence Office. She is responsible for the oversight of Over-Head Persistent Infrared capability - the infrared satellite capability that supports missile warning, ballistic missile defense, technical intelligence, and battlespace characterization. She received her BS degree in electrical engineering from Union College, and her Ph.D. from the University of Massachusetts, Amherst.

Part IV: Poster Session

Computer-assisted Language Learning and Computer-assisted Text Exploration Today

Harry Diakoff, The Alpheios Project, Ltd.

Computational linguistics and digital text mining are two of the most obvious areas in which humanities scholars and engineers, specifically computer scientists, are necessary collaborators. A number of concordances and digital editions of specific works and authors already illustrate the potential of such collaboration, but the appearance of larger and larger digital corpora is significantly increasing the opportunities for both research and pedagogical applications. Unlike the universal language of mathematics that unites the sciences and the engineering disciplines, the humanities are divided by a multiplicity of natural languages. Coping with the challenges that this situation creates has always been a significant part of humanistic training and practice. We should like to demonstrate a few of the ways that current technology can help address these challenges- both to facilitate research in texts whose language may be unfamiliar and to facilitate the study of a language itself. We focus on tools available in the open-source world because it is there that the ambitious entrepreneur is most likely to find the resources needed to create the new tools that will address the every changing needs of humanities scholars and their students. We should like to review some examples of tools for: - the automatic alignment of texts and translations - derivation of dynamic lexica from such alignments - automatic morphological and syntactic analysis - machine translation - collaborative annotation and discussion of texts - text mining for named entities, concepts and allusions - reading support for unfamiliar languages - "computer assisted language learning" (CALL and ICALL).

E 4 E: Engineering for Educators

Dan Dimitriu, Jerry O'Connor, San Antonio College

K-12 science and math education is part of the Administration's American Competitiveness Initiative (ACI). As one part of the larger initiative that seeks to encourage research and development, innovation, and global competitiveness, the education arm of the ACI proposes new Federal support to improve the quality of math, science, and technological education in K-12 schools.

Recent data confirm that teaching is not an easy profession: A new study from the National Center for Education Statistics, for example, shows that 8 percent of public school teachers—and fully 20 percent of brand new teachers—quit the classroom in the 2004-05 school year.

Yet teaching remains a source of fulfillment and intellectual excitement for many thousands of educators, and continues to speak to the interests and ideals of many young people and mid-career professionals.

So, what can be done to help teachers find new ideas that will attract and excite students to learn difficult subjects such as Math and Science?

There is one answer: By helping teachers become themselves more interested and excited about these subjects! That means exposing teachers to the most exciting and the least understood profession which is engineering!

Why? Because:

1. It will help teachers understand the importance of relating Math and Science to Engineering and real life in their lessons.
2. It will provide math and science teachers with resources that will help them to introduce the basic Engineering principles in their classrooms.

3. It will help math and science teachers develop the ability to teach problem solving skills.
4. It will make math and science teachers more aware of the world around them.

Science is the art of obtaining knowledge. Engineering is the art of using knowledge to achieve objectives and solve problems. If we put them together in the class room early enough we have better chances to raise more interested and dedicated students.

Measuring Student Learning Gains in Engineering and Humanities Integration

Tim Foutz, Kerri Patrick Singer, Maria Navarro, Sid Thompson, The University of Georgia

Similar to engineering departments across the USA, most engineering faculty at The University of Georgia do not have academic backgrounds in the humanities and although several faculty members are willing to make an attempt at integrating topics from the humanities into engineering course materials, they are finding it challenging to do so. The goal of this research project is to help engineering faculty overcome this challenge by providing the following:

1. Guidelines for developing course materials with helping students connect the humanities with engineering and
2. Exemplar material that will assist engineering faculty wishing to follow these guidelines.

An interdisciplinary Model Teaching Team developed five guiding principles of essential skills needed to help student make this integration, and a learning module entitled, The Water Module, was developed as a ways to incorporate these principles into an engineering course. The module was presented to engineering faculty and was implemented into two engineering courses. The results indicate that the treatment group had a clearer understanding of how the humanities are imbedded in engineering practice.

Employing Second Life Modeling to Explore Life After Death

Ashraf Ghaly, Union College

"Union College considers its commitment to international programs to be a central part of its identity. In addition to broadening a student's perspective and deepening their knowledge of other cultures, international programs often energize and challenge a student to a higher level of commitment to the enterprise of learning." Within this framework, a miniterm in Egypt has been structured to fulfill a vision of integrating the liberal arts/humanities with engineering/architecture. The program of the miniterm in Egypt involves visits to most famous and structurally impressive temples and monuments. This includes the only remaining one of the ancient seven wonders: the Pyramids. Ancient Egyptians' belief system revolved around the preservation of the dead body for the eventual return of the soul after death. Preservation involved mummification of the body, and concealing the burial place to evade tomb robbers looking for treasures hidden with the dead. Ancient Egyptians went to unprecedented lengths in designing and building these monumental structures. Impressive as they look on the outside, the unseen inside is, by far, much more impressive. An elaborate and sophisticated maze of tunnels and hallways were meticulously distributed throughout these pyramids. Except for one, all these tunnels lead to dead ends and are only constructed to mislead and demoralize tomb robbers. The body of the king was buried in a chamber the concealment of which was a supernatural design feat. Models of two of Egypt's best-known pyramids; the Great Pyramid of Giza and the Stepped Pyramid of Saqqra, were realistically built in Second Life's (SL) environment. The semi-transparent models allow the viewer to have a sensible 3D view of the network of tunnels and hallways inside each pyramid. SL's environment allows the user to

walk-through or fly-over various features, and to develop a sense of appreciation of the scope and magnitude of the elements unseen from the outside of a pyramid. These models helped the students understand how faith in the afterlife impacted the design and construction of structures in real life.

Going Boldly – Creating the New Engineering Education

Peter Golding, Juliette Caire, Blanca Carrasco, Eric A. Freudenthal, Gilberto Moreno Jr., Richard F. O'Brien, Ricardo L. Pineda, Michael T. Pitcher, Stella A. Quinones, Joseph P. Ramos, Richard T. Schoephoerster & Elsa Q. Villa

UTEP is boldly advancing integration of engineering, technology and liberal education at a public, urban, university with a 21st demographic. We are creating a new undergraduate degree program in Leadership Engineering as part and parcel of moving to achieve a new paradigm for an engineering education. Other components of the overarching programs development at UTEP include professional graduate degrees in engineering education and engineering arts and sciences. The new programs will provide a tangible new footprint for the engineering – liberal arts community pathway as they present a dramatic functional shift in engineering education.

We are moving our unique institution of higher learning, accompanied and in cohort with enlightened partners, including alumni and industry, to help our diverse and talented students see education in a strategic context, as an enterprise effort, if you will. Following Rainey (2002), we know that to compete in newly emerging markets, both academia and industry must commit to technological changes and innovation and that the role of the enlightened engineer is crucial to this. As Vicki Rainey recognized almost a decade ago (quote) "industry and higher education must come together to foster a lifelong commitment to learning. Educators and corporations must stop looking at the engineering curriculum as a four-year, fact-filled curriculum. They must begin thinking of engineering as a (lifelong) curriculum addressing the mental, emotional, physical, and social aspects of the student's life. Transdisciplinary approaches are a means to this end." (Rainey 2002). We need to move this way for, as Jackson (2004) notes, (quote) "this is the way our children are growing up. This is the context in which we must teach them — how we must reach them. Reach them where they are."

A whole new mindset is required to succeed in engineering, beyond the technical education that has been the hallmark of land-grant institutions of higher learning, which were central to advancing our rural, agricultural-centered economy of the 19th century, and then adapted to support the industrialization that drove the economy of the 20th century. Our UTEP approach is consistent with following recommendations from two 2008 reports on the future of engineering education. The Carnegie Foundation for the Advancement of Teaching report Educating Engineers: Designing for the Future of the Field (2008) established the "imperative for teaching for professional practice" in engineering education by providing the "engineering equivalent of the clinical dimension of medical preparation" that includes a "place to explore professional practice", not unlike the clinical sites utilized for the preparation of physicians. Dr. James Duderstadt's report Engineering for a Changing World (2008) recommends the establishment of "graduate professional schools of engineering that would offer practice-based degrees at the post-baccalaureate level as the entry degree into the engineering profession," again using the training of physicians as an appropriate model. He also recommends the formation of "Discovery-Innovation Institutes," academia-industry-government partnerships for engineering, a cross between academic medical centers where

education, research, and practice are synergistically united within one unit, and corporate R&D laboratories that link fundamental discoveries to innovative products and services through applied research.

Leadership Engineering is the first step in helping our students in an education context that promotes and supports practices that foster teamwork and integrity in professional and personal development. As Jackson says (2008), this (quote) "aids in the coalescence of varying perspectives (and) often helps to highlight, and to clarify, issues and potential ethical questions — questions which might escape notice, or mention, among same-discipline colleagues." (It promotes) "understanding of vision, culture, and values in the corporate and public worlds. Leadership education provides models and methods for problem- solving, and enables students to test personal limits, and to explore cultural assumptions. Leadership education promotes collaboration, effective communication and feedback, conflict management, team development, and ethical decision-making. Through interactive, experiential learning, students are exposed to specific leadership theories, and they learn motivation techniques and tools to succeed in a diverse organizational culture. In short, leadership education and the professional development (that) it entails, gives students a head start for functioning in the corporate and the larger world."

Rainey (2002) envisions such transdisciplinary education as UTEP is pursuing may make it possible to realize a profession composed of teams of engineers acting as a single engineer, as described by Alexander Solzhenitsyn: "An engineer? I had grown up around engineers, and I could remember the engineers of the twenties very well indeed; their open shining intellects, their free and gentle humor, their agility and breadth of thought, the ease with which they shifted from one engineering field to another and, for that matter, from technology to social concerns and art. Then too, they personified good manners and delicacy of taste; well-bred speech that flowed evenly and was free of uncultured words; one of them might play a musical instrument, another dabble in painting; and their faces always bore a spiritual imprint."

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A Case for Integration: The Deepwater Horizon Oil Spill

Andrew Guswa, Elisabeth Armstrong, Michael Barresi, Ann Leone, Catherine McCune, Donna Riley, Susan Sayre, Elizabeth Spelman, Smith College

During the 2010-11 academic year, the Center for the Environment, Ecological Design and Sustainability coordinated a faculty learning community on the Deepwater Horizon oil spill. This venture brought together faculty who were interested in incorporating elements of this case into their courses. This cross-disciplinary community shared knowledge and perspectives on the events, and all participants gained a deeper sense of the issues. Specific projects were developed for courses in Comparative Literature and Landscape Studies (the rhetoric of the spill),

Mathematics (using the spill to teach quantitative literacy), the Study of Women and Gender (community-based projects on spill-based campaigns led by social movements), Economics (valuing environmental resources), Philosophy (governmental oversight), Biological Sciences (effect of crude oil and dispersants on embryonic development of zebrafish), and Engineering (two projects: modeling fate and transport of the oil; engineering culture and ethics). This poster presents the descriptions, results, and impacts of these projects.

Teaching With GarageBand

Linda Head, Philip Mease, Thomas Traub, Rowan University

A second semester of the General Education course Signals, Systems and Music is benefitting from a new curricular strategy and a new hardware laboratory. These aspects of the course are interdependent and are creating an environment more conducive to the integrative endeavor that is the goal of this course. The laboratory designed and implemented for Signals, Systems and Music includes both a thirty-seat lecture space and ten stations for electronic music composition. Each of the composition stations includes: function generator, oscilloscope, audio interface/amplifier, power supply, multimeter, midi keyboard and iMAC. The availability of the dual boot iMAC (and prior experience with a share-ware Digital Audio Workstation (DAW)) led us to redesign the course around the latest version of the Apple application, GarageBand. Using GarageBand gives the students a familiar interface with powerful features so they can concentrate on the creative aspects of using the tools of music theory and engineering principles to "design" a musical composition.

The new laboratory and software tool prompted a redesign of our laboratory procedures and instructions that now focus more on the integration of music theory with the engineering principles of sound and structure. The ability to dispense with the extensive learning curve associated with the previous DAW provides a smoother integration between music theory and laboratory portions of the course.

The poster presentation will include an overview of the laboratory sessions, some details of the music theory instruction and video and audio of final presentations of student compositions.

Integrating Legal Education into the Engineering Curriculum

Martin High, Oklahoma State University

A novel curriculum has been designed involving the legal aspects of engineering as they apply to technology practice. The purpose of the curriculum is two-fold: 1) to make technical professionals aware of how engineering practice relates to an organization's legal duties and 2) to encourage those professionals to engage in policy debates that shape business regulation and the common law. This paper will briefly outline the overall program which involves four newly developed courses, and focus on the content of one of those courses, Tort and Products Liability Law for Technical Professionals. From an educational perspective, the curriculum is a logical extension of traditional science and engineering education in that it demonstrates the practical and economic importance of applying sound technical skills. More important, it provides business with technologists who recognize the economic value of responsible design practices. Society, in turn, benefits from better, safer products and processes, and from legal systems and processes that better reflect the unique challenges of technology practice.

A Writing Intensive Cornerstone Course for STEM Students

Clif Kussmaul, Jane Flood, Muhlenberg College

In 2010, Muhlenberg College received a NSF S-STEM grant for Scholarships in Math & Science (SIMS), a project to improve recruitment and retention in the mathematical and physical sciences. Key components include financial aid, a cornerstone course, a colloquium, academic support (advising, pre-orientation, mentoring, and learning assistants), and a faculty learning community. At Muhlenberg, all students take a FYS to develop critical thinking, research, & writing skills. The SIMS students' FYS is inspired by cornerstone courses at other institutions, and is organized around multidisciplinary design projects, including a pookalam (south Indian flower design), musical percussion instruments, and a series of proposals for new commercial products. Other course components included: active-, inquiry-, and team-based learning activities; and reading, writing, and discussing a variety of articles, chapters, and essays. We will describe the FYS structure, activities, and outcomes in more detail, summarize results to date, and outline directions for future work. Supported in part by NSF DUE-0965834.

Collaborative Work between Music and Electrical Engineering at Union College

Dianne McMullen, Helen Hanson, Palma Catravas, Union College

Over the course of more than half a dozen years we have brought students together from our disciplines, electrical engineering on the one hand and music history and performance practice on the other. We will provide updated information about the processes by which we collaborate, which are based on short interactions ("interdisciplinary lightning") between courses in our fields. Each course contains fundamental disciplinary material, the mastery of which is critical to the students' future work. We enjoy finding novel methods to reinforce these disciplinary fundamentals through the interdisciplinary interactions and will describe examples. At the same time, we have observed a significant growth in each group's communication skills and desire on the part of the students to learn more about the other area of expertise. The opening of a brand-new facility, the Laboratory for Electrical Engineering and Music Research, will be described.

Literature and Science: Designing Courses to Appeal to Science and Engineering Majors

Anastasia Pease, Union College

This presentation (or poster) will focus on two Literature courses designed to appeal to students in Science and Engineering -- "Science Fiction" and "Literature and Science." "Science Fiction" is a popular general education course. Its main strength is that it gives students in all majors a chance to explore the genre that is traditionally considered less threatening than "serious" literature. However, students discover (often to their surprise) that Science Fiction can and often is "serious" literature, and that they can think and write intelligently about exceptional literary texts. This course also engages students in discussing technology, ethics, biology, bioethics, and cyborg anthropology, among many other topics of interest. "Literature and Science" is another gen-ed course designed to appeal to Science and Engineering majors. The texts are chosen from a long list of works by scientists in many different fields, from physics and biology to neuroscience. Some texts are literary, some scholarly, some popular. The course has two rubrics: texts by scientists and the latest science of the reading brain. Students are often surprised to discover the many connections between these two seemingly separate realms. I have taught both courses at Union in the last four years, so my presentation

will also discuss the syllabi, the challenges, and my students' reactions to the material.

"Smarter Planet" (IBM) Sophomore Research Seminars at Union College

Mark Walker, Union College

IBM's "Smarter Planet" initiative uses data and computing to make systems smarter and more efficient, thereby helping the environment, economies, and societies. The program is broken down into ten sections: banking; communications; electronics, automotive, aerospace; government; healthcare; insurance; oil and gas; retail; and transportation. Union College will collaborate with IBM's "Smarter Planet" by teaching sophomore research seminars, team-taught by a Union professor from engineering or science and one from the humanities or social sciences, on a "Smarter Planet" theme. These seminars will also work closely with a researcher from IBM. The specific subjects of the seminars will vary over time, but all will teach students how to do interdisciplinary group research. Students with different kinds of interests and skills are welcome. This is not just something for engineers; rather we want classes with students from the humanities, social sciences, sciences, and engineering.

Part V: Practicing Integration

Toward Routine, Low-Cost Intrinsic Motivation Course Conversion

David E. Goldberg, Geoffrey Herman, Jonathan D. Stolk, & Mark Somerville, Olin-Illinois Partnership

Active learning and problem-based learning have received considerable attention in the literature on engineering education; the methods for converting the sage on the stage to the guide on the side are well researched, understood, and disseminated, and these techniques are often believed to be on the royal road to the integration of engineering and liberal education. Yet, the move to a more student-centered classroom is largely confined to those individual faculty members or institutions with exceedingly strong commitment to excellence in education. Much of the engineering academy remains inhabited with sage faculty, economically recycling 20-year old course notes, in traditional lecture settings, using traditional classroom inputs such as texts, problem sets, quizzes, exams, and the like. Here we argue that this state of affairs is no accident, that the root cause of the situation may be understood through the lens of incentives and economics, that the way out is to stop thinking of the faculty member as the primary actor in the classroom. Starting from an understanding of what has come to be called the Goldberg-Laffer Curve of Engineering Education, we question the very language of the sage and guide as too focused on the faculty member, and wonder what would happen if the emphasis were shifted to the learner with fervor. This leads us to recommend the development of an intrinsic motivation conversion process in which responsibility for learning is largely shifted to the student and the faculty member becomes more of a coach or facilitator. Borrowing from the IM and learning research of Rogers, Deci, Ryan, Dweck, and others as popularized by such current business books as Drive and Switch, we take years of learning and educational research into handcrafted IM classrooms at Olin College and design a more factory-like IM conversion process for utilization where the economics of teaching and research are a major concern. Pilots of the proposed process are slated for Fall 2011 at the University of Illinois, and the presentation concludes with a conceptual outline of an IM conversion process, resource and training requirements, and expected concerns and opportunities, especially in the domain of integrating engineering and liberal education.

Critical Thinking for Early Engineering Students: From Project Reports to Reflections to Journaling

Karen High, Rebecca Damron, Oklahoma State University

For the engineering educator, implementing and integrating the professional, institutional, and pedagogical goals and expectations into a course is complex and becomes much more so when developing curricula for early college students. These students are not always comfortable with problem posing situations, and as the tasks increase in complexity, so does the difficulty in thinking and writing about those tasks (Bean, 2001). Evolving since 2005, the authors (faculty members in English and Engineering) have integrated problem-posing into early (Freshman/Sophomore) engineering classes by using a model of critical thinking (Foundation for Critical Thinking) to structure writing assignments requiring students to report about in-class, team-based activities and apply them to engineering concepts. The form of these reports has been as project reports and reflections. As part of this work, writing fellows (upper class engineering students) have been engaged as peer tutors. The Writing Fellows in evaluate drafts of the written work as well as engage

the students in discussions about their work. In 2010, sophomore chemical engineering students were engaged in journaling to enhance critical thinking and writing. The students reflected about the American Institute of Chemical Engineering (AIChE) Chemical Car college student competition. Students posed positions on topics such as reaction selection, calibration, and mechanism of car movement. Journaling has been expanded in 2011 to include topics relevant to course materials. This presentation will demonstrate mechanisms for integrating critical thinking and writing into early engineering courses.

Can Students Be Taught To Be Creative?

Joseph Tranquillo, Bucknell University

There are often times during the design process when instructors say, "Generate alternative solutions", or "Be creative". Is there any way to teach, or for students to learn, to be creative? Can we give our students better direction? We present a framework designed to help students navigate the portions of the design process that require creativity. A systems view of creativity is presented that is grounded in technical concepts such as network theory, game theory and self-organized criticality. Several example systems are shown (e.g. economies, ecosystems, cells) and reoccurring patterns are pointed out (e.g. scale-free networks, self-organized to a point of criticality) that enable these systems to generate novelty. Familiar brainstorming techniques such as Osborn's Rules and de Bono's Six Hats can easily be mapped to the framework. Thinking of creativity as a complex adaptive system also provides a way for the instructor to diagnose creative diseases. When the framework is shared with students, it empowers them to construct their own creative environments. Some results are that students view tension and regular self and team reflection as vital components of the creative process. Teaching the framework can easily be packaged into a self-contained unit, or scattered throughout a course. Furthermore, we have found that the scientific grounding of the framework resonates with engineering undergraduates. Data from the literature and student assessment data will be used to support the conclusions.

Part VI: i2i Faculty Institute

Fostering Integration: Faculty Learning Communities

Workshop Coordinators from Smith College: Andrew Guswa, Associate Professor, Engineering, Director, Center for the Environment, Ecological Design and Sustainability; Elisabeth Armstrong, Associate Professor, Study of Women and Gender; Ann Leone, Professor, French and Landscape Studies; Susan Sayre, Assistant Professor, Economics

Complex societal challenges cannot be addressed nor even understood through the lens of a single discipline. Rather, innovative thinking and solutions require the integration of knowledge from multiple fields. How can faculty help foster a culture of integrative thinking? This interactive workshop will engage participants from a range of disciplines in exploring how to build such a culture with an eye to increasing capacity for innovation. The workshop will begin with results from a Faculty Learning Community piloted at Smith College in 2011-2012 and includes examples of how the Deepwater Horizon crisis has been incorporated in courses from comparative literature, engineering, economics, and the study of women and gender. All participants will then engage in an interactive session on other contemporaneous cases, identifying and articulating questions and ideas relevant to courses they teach. In this way, participants will gain insight to epistemologies and modes of inquiry from other disciplines. This will be followed by development of ideas for class exercises, assignments, and interactions based on generative and integrative thinking. The workshop will conclude with a meta-analysis of the structure and implementation of the Faculty Learning Community offered at Smith this past year and the associated advantages, disadvantages, and observations.

The Intellectual and Practical Challenges of Integrated Teaching

David Goldberg, ThreeJoy Associates, Inc.; Doug Klein, Dean of Interdisciplinary Studies, Union College, Cherrice Traver, Dean of Engineering, Union College

This workshop examines the challenges of working with faculty from other disciplines and of initiating and implementing interdisciplinary courses, programs, and events. Many of these challenges revolve around perceptions and language that are so engrained in our existence that we fail to recognize the role they play in our interactions. Workshop participants will participate in exercises that reveal these subtle barriers and provide intellectual frameworks and practical techniques that enable new perspectives and possibilities. The workshop starts with an interactive group exercise with a scenario that exposes tensions and communication breakdowns. This is followed by an exploration of the philosophy of speech acts and the connections to the scenario. The session will conclude with a third interactive exercise that emphasizes deep listening and asking powerful questions.

Reaching Across the Disciplines: Facing the Ethical Issues of a Technologically Complex World

George Catalano, Binghamton University

We shall explore, in a highly interactive and experiential format, ethical dilemmas that

often confront us in our ever more complex world as a mechanism whereby the liberal arts can be integrated into our classrooms. Using a course module approach, participants will first encounter existing case studies such as the tragedy of the 2010 Gulf of Mexico oil spill. Ideas presented in my new book, *Tragedy in the Gulf: A Call for a New Engineering Ethic*, will serve as a springboard for this workshop. Disciplines from both within engineering as well as the liberal arts offer perspectives that will be included in our exploration of this accident. Subsequently participants shall develop the framework for integrating a similar case into courses they will teach in the near future. Participants will leave the workshop with an identified course, a milestone schedule of required developments, a specific issue and an assessment strategy each will integrate into their respective course.

Pedagogies for Bridging the Engineering and Humanities Disciplines

Tim Foutz, The University of Georgia
Maria Navarro, The University of Georgia

This workshop will present results from a 3-year project to help engineering faculty bridge the gap between the humanities and engineering. It will include

- guidelines for developing course materials that help students connect the humanities with engineering and
- exercises for developing example material that will assist engineering faculty wishing to follow these guidelines.

Project Background: A learning module entitled, The Water Module, was created to provide an instructional method of integrating the humanities into engineering courses. An Interdisciplinary Consultant Team was established to determine what skills students needed in order to make this integration. This Team established five guiding principles of essential skills, and the Water Module was created as a way to incorporate these principles into an engineering course. This module was implemented into a freshman engineering course. Interviews were used to gather students' reactions to this module and to evaluate the module's success in teaching students this integration. A control group was used to compare other instructional methods against the module. The results indicate that the treatment group had a clearer understanding of how the humanities are imbedded in engineering practice. Our workshop will present this learning module for integrating the humanities into engineering coursework.

Learning Objectives

- To discuss the knowledge base that faculty from humanities and social science indicate is needed to be able to work in the "soft science" issues related to engineering activities
- To examine this technique for infusing humanities and social science topics into engineering course material

Part VII: Appendix

Participants

Bibliography

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Back Cover: The second floor railing of the recently dedicated Peter Irving Wold Center at Union College. The oxygen emission spectrum integrated into the railing symbolizes that there are fundamental elements in life, just as there are common aspects of teaching and research that take place in disparate disciplines.

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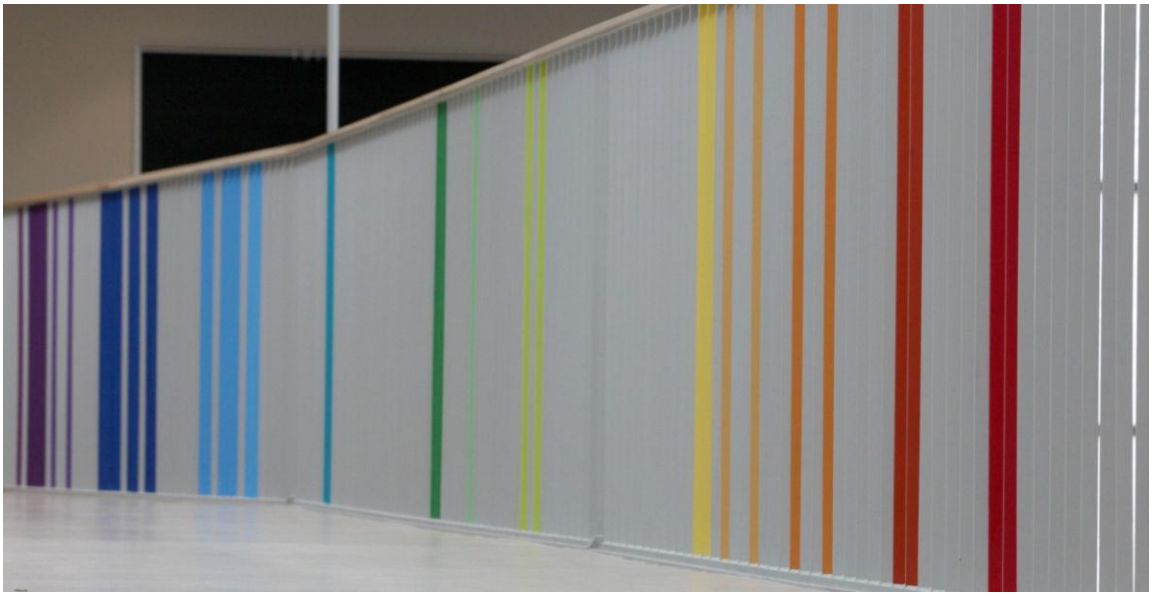

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