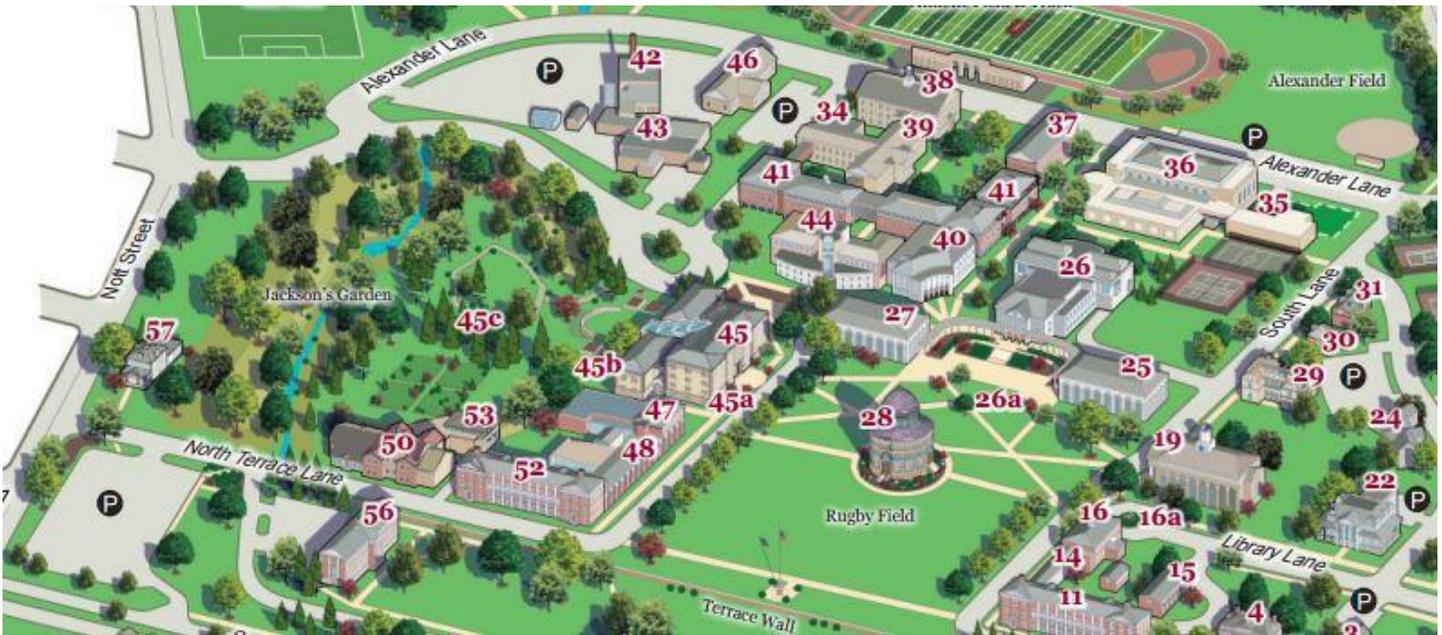


EIGHTH SYMPOSIUM ON ENGINEERING AND LIBERAL EDUCATION



**5-6 JUNE 2015
UNION COLLEGE
SCHENECTADY, NEW YORK**

CAMPUS MAP



16 Hale House

28 Nott Memori

40 Wold Center

Trolley Schedule

The Trolley will make several round trips throughout the hour, beginning with the times below:

Friday 5 June

11:00 am Hampton Inn to Old Chapel Circle
8:30 pm Old Chapel Circle to the Hampton Inn

Saturday 6 June

7:45 am Hampton Inn to Old Chapel Circle
4:30 pm Reamer Circle to Hampton Inn

On the cover: 3D printed model (from the Union College Collaborative Design Studio) of the Nott Memorial in the foreground of the building itself. (Photo Credit: Dylan Cline, Mechanical Engineering, '16)

WELCOME

Welcome to the Eighth Symposium on Engineering and Liberal Education, hosted by Union College in Schenectady, New York.

We are incredibly grateful to have Hod Lipson, Professor of Engineering at Cornell University with us to present the keynote address.

We have an outstanding array of papers and exciting interactive sessions from researchers and practitioners at the interface of engineering and the liberal arts. We have integrated these into an exciting program that we hope will result in you bringing home some practical applications of this work.

On behalf of the Program Committee, we welcome you to our beautiful campus and hope that you have an inspiring symposium.

Shane Cotter, Symposium Chair

PROGRAM COMMITTEE

Chair

Shane Cotter
Director of Engineering
Associate Professor of Electrical Engineering
Union College

Members

Atsushi Akera
Associate Professor
Department of Science and Technology Studies
Rensselaer Polytechnic Institute

Dave Hans
Manager, z/OS User Technologies
IBM Systems Group

Christine Henseler
Professor of Spanish & Hispanic Studies
Chair of Modern Languages & Literatures
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J. Douglass Klein
Kenneth B. Sharpe Professor of Economics
Director, Environmental Science, Policy and
Engineering (ESPE)
Union College

John Rieffel
Assistant Professor
Department of Computer Science

Symposium Staff

Karen Crosby, Administrative Assistant for Academic Affairs

ACKNOWLEDGEMENT OF SUPPORT

We gratefully acknowledge the support of the Laurence W. Levine '52 and Barry Traub '53 Endowed Lecture Fund on the Liberal Arts and Engineering. This fund has helped us bring to campus a leading engineer who is also a leading proponent of the liberal arts. We further acknowledge the support of the Union College Office of Academic Affairs.

Special thanks to the Union College Facilities, Media and Dining Services staff, without whom this event would not be possible.

SYMPOSIUM PROGRAM

Friday 5 June

11-1:00pm	Check-in	<i>Hale House</i>
12-1:00pm	Lunch	<i>Hale House</i>
1-3:00pm	Special Session 1	<i>Hale House</i>
	Exploring the Aesthetic and Humanistic Dimensions of Maker Culture	
3-3:30pm	Break	<i>Everest Lounge</i>
3:30-5:00pm	Special Session II	<i>Hale House</i>
	Applying Design Thinking to Create Effective Makerspaces	
5-6:00pm	Reception	<i>Nott Memorial</i>
6:00pm	Welcome Address	<i>Nott Memorial</i>
	Dr. Stephen C. Ainlay, President, Union College	
6:00-7:00pm	Keynote Address: 3D Printing: The Next 25 Years	<i>Nott Memorial</i>
	Hod Lipson, Professor of Engineering, Cornell University	
7-9:00pm	Dinner	<i>Hale House</i>

Saturday 6 June

8-10:00am **Breakfast** *Wold Building*

8:30-10:00 **Breakfast Panel: New Programs at the Intersection of Liberal Arts and Engineering**

Making and Liberal Studies in Engineering

Diane Michelfelder, Macalester College

Louis Bucciarelli, MIT

Going From Designing the Engineering Education of the 21st Century to Making it a Reality

Fatma Mili, Sorin Matei, Michael Cunning, Robert Herrick

Purdue University

Modeling Liberal Arts and Engineering Integration in a New Degree

Chell Roberts, University of San Diego

10-11:30am **Engineering Design and Grand Challenges** *Wold Atrium*

The Engineering Grand Challenges at a Liberal Arts University

James Van Fleet, Bucknell

Educating for Innovation: Training Engineers in Creative Problem Solving

R. David Kent, Milwaukee School of Engineering

Digital Short Courses for Multidisciplinary Engineering Education

Alex Dale, Engineers for a Sustainable World

Erin Lennox, Rensselaer Polytechnic Institute

Making the Maker Faire Fair: The difficulties of managing academic instructional and assessment needs with interdisciplinary project-based learning, while also managing complex non-university partnership expectations and real-world project production

*David Gillette, Michael Haungs, Jane Lehr, Elizabeth Lowham
California Polytechnic State University*

Knowing Who Knows: Teaching Assistants as Learning Brokers in Engineering Education

Michael Lanchney & David Banks, Rensselaer Polytechnic Institute

11:30-12pm **Break** *Wold Atrium*

12-1:30pm **Two Parallel Sessions: Making and Pedagogy** *Lippman Hall*

Making (Lippman 016)

Discovery Lab - A Space for Electrical Extracurricular Projects

Jim Hedrick, Union College

Making on the Margins: Possibilities for Making and Hacking as Informed by Feminist Critique and STS

Ellen Foster, Rensselaer Polytechnic Institute

Materials Thinking

Ulrike G.K. Wegst, Ayan Azmat, Andrew L. Beaubien, Amaris A. De La Rosa-Moreno, Mackenzie L. Carlson, Kevin R. Baron

Dartmouth College

Treasure Wild Ducks...Because They Contribute to Designing and Making

Molly Stevens, IBM

Pedagogy (Lippman 017)

Does Studying Music Enhance Higher Order Learning Skills in Undergraduate Non-Music Majors?

*Kathryn Evans, Frank Dufour, Rosanna Guadagno, and Roger Malina
UT Dallas*

Integrating Socio-History Into an Introductory International Business Course

Rafael Burgos, UMass Amherst

Teaching at the Intersection of Engineering and the Liberal Arts

*Peter Westin, Ben Laugelli, Doulgass Reed, W. Bernard Carlson
University of Virginia*

Engineering Design: A Technology Teacher's Perspective

Melissa Hirt, Albany Public Schools

Environmental Forensics: A Conduit to Teach Science, Engineering, Ethics, Law, Policy, Economics, And Sustainability

Ashraf Ghaly, Union College

1:30-2:30pm **Lunch** *Wold Atrium*

2:30-4:30pm **Special Session III** *Wold Atrium*

**(Re)Making a Design Major/Studio: A Hands-On Workshop
For Creating/Transforming an Integrative Design Experience**

4:30-5:30pm **Ice Cream Social** *Reamer Campus Center*

KEYNOTE ADDRESS

3D Printing: The Next 25 Years

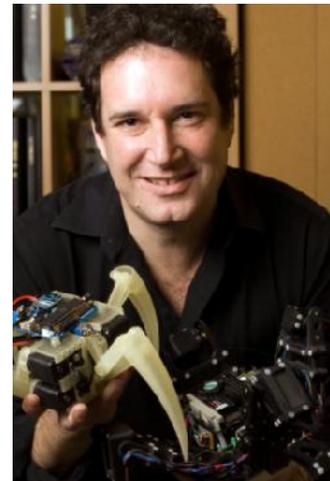
The Promise and Peril of a Machine That Can Make (Almost) Anything

Hod Lipson

Professor of Engineering, Cornell University

Abstract

3D Printers – machines that can automatically fabricate arbitrarily-shaped objects from almost any material – have evolved over the last three decades from limited and expensive prototyping equipment in the hands of few, to small-scale commodity production tools available to almost anyone. It’s been broadly recognized that this burgeoning industrial revolution will transform almost every industry, and every aspect of our lives. But where will this technology go next? This talk will describe why 3D printing is disruptive, and look at the evolution of additive manufacturing from its past to its future. The technology is advancing from printing parts in plastic and metal, to bio-printing and food printing, and from 3D printing passive parts to printing active, integrated systems, including electronics, actuators and sensors. Will we one day be able to print a robot that will walk out of the printer, batteries included?



Biography

Hod Lipson is a professor of engineering at Cornell University in Ithaca, New York, and a co-author of the award-winning bestseller “Fabricated: The New World of 3D printing”, now translated to seven languages. His work on self-aware and self-replicating robots, food printing, and bio-printing has received widespread media coverage including The New York Times, The Wall Street Journal, Newsweek, Time, CNN, and the National Public Radio. Lipson has co-authored over 200 technical papers and speaks frequently at high-profile venues such as TED and the US National Academies. Hod directs the Creative Machines Lab, which pioneers new ways to make machines that create, and machines that are creative. For more information visit <http://lipson.mae.cornell.edu>.

SPECIAL SESSION DESCRIPTIONS

SPECIAL SESSION I: EXPLORING THE AESTHETIC & HUMANISTIC DIMENSIONS OF MAKER CULTURE

Christine Henseler, Union College

Atsushi Akera & Ellen Foster, Rensselaer Polytechnic Institute

PRESENTATIONS:

ELLEN FOSTER, RENSSELAER POLYTECHNIC INSTITUTE

JENN KARSON AND DOUG WEBSTER, UNIVERSITY OF VERMONT

ARIEL NERESON, VASSAR COLLEGE

JOHN RIEFFEL, UNION COLLEGE

MARGOT VIGEANT, BUCKNELL UNIVERSITY

Maker spaces draw on many different cultural elements, from the traditional crafts, to high-tech entrepreneurship, to urban countercultures and even class-based oppositional movements.

While there are also clear humanistic and aesthetic dimensions to the movement, both in the artifacts produced in maker spaces, as well as in the institutional forms created to support maker spaces, these two aspects of maker spaces have yet to receive full articulation.

At the 2015 Union College Symposium, we will convene a NY6 Think Tank session for exploring the humanistic and aesthetic dimensions of the contemporary maker spaces movement, and of maker culture as a whole. We are fortunate to have as our opening speaker Jentry Sayers, editor of “Making Humanities Matter. His talk will be on “Prototyping as Inquiry in the Arts and Humanities” and will help set the tone for the activities to follow. This will be followed by brief presentations by those who have been involved in creating maker spaces with the “issues” (and opportunities) surrounding the arts and humanities that have arisen in the design and development of their spaces. (We will be using a modified Pecha-Kucha format—15 slides @ 20 seconds each). We will then divide up into teams that will be tasked not only to explore, but to create (i.e. make) solutions for the issue or issues they identified through a variety of structured activities ranging from concept generation to the aesthetic rendering of their ideas, and documenting these ideas both through auto-ethnography and the collection of our output. As consistent with the concept of the NY6 Think Tank, our ultimate goal will be that of producing a public article, blog, performance piece, installation, and/or student exercises and learning modules that will help disseminate the ideas that we produce during this hands-on concept-building session.

SPECIAL SESSION I INVITED TALK:

PROTOTYPING AS INQUIRY IN THE ARTS AND HUMANITIES

JENTERY SAYERS

UNIVERSITY OF VICTORIA

Anchored in critiques of media through new media practice, this talk explores prototyping as inquiry in the arts and humanities, with a focus on wearables, electronics, and fabrication research. I argue that prototyping fosters rich understandings of: 1) how this becomes that, 2) how technologies are embedded in culture, 3) the sources, endurance, and afterlives of objects, 4) speculation and conjecture as critical methods, and 5) how discourse and matter are intertwined. In so doing, I draw upon research from the University of Victoria's Maker Lab in the Humanities "Kits for Cultural History" project (<http://maker.uvic.ca/kch/>), which prototypes inaccessible technologies dating back to the 1800s. One such prototype is an "early wearable kit" that allows audiences to not only reassemble electric jewelry from the second half of the nineteenth century but also contextualize the jewelry's social functions. To create these prototypes, Maker Lab researchers combined patents, designs, notes, biography, and news media from the 1800s with techniques in sculpture, physical computing, computer-aided manufacturing, and structured-light 3D scanning. After arguing for the relevance of prototyping to arts and humanities inquiry, this talk navigates audiences through the process of making the early wearable kit and concludes with its implications for history and material culture studies.

Funding for this session and our invited speaker has been provided through the NY6 Think Tank



With the support of the Andrew W. Mellon Foundation, the New York 6 Liberal Arts Consortium is building a community comprised of professionals and students who wish to transform—rethink and rewrite—public conversations on the state of the Arts and Humanities. This group is called the NY6 Think Tank.

SPECIAL SESSION II: APPLYING DESIGN THINKING TO CREATE EFFECTIVE MAKERSPACES IN ENGINEERING

Dave Hans, Laura Barrera, Toshiba Burns-Johnson, Jodi Everdon, Cheryl Loughlin, Kirsten McDonald, Barbara Neumann, Molly Stevens
IBM

Design Thinking, or “design as a way of thinking in the sciences” is a recognized and highly valued customer focused process. While Design Thinking had its beginnings in the late 1960’s, it was Stanford Professor, David Kelley, who adapted Design Thinking for business needs, and founded the Globally recognized IDEO design centers. Design Thinking is the leading process that has transformed the design mission for companies like Google and Microsoft. Three years ago, IBM, under the direction of current CEO, Ginni Rommety created a strategic reshaping of IBM Design, by developing the IBM Design Thinking process. At the core of IBM Design Thinking is the need to develop teams and Agile work spaces that promote open and effective team communication.

Using the concepts of Design Thinking to guide discussion, we will create several small teams to engage in an interactive workshop to identify and prioritize critical aspects of effective MakerSpaces. Teams will use an ideation exercise to explore and share ideas, before prioritizing input for a model space. We will then share and discuss some of the proposed model MakerSpaces. We will close the workshop with a short presentation of some current Design Space activity underway across IBM.

SPECIAL SESSION III: (RE)MAKING A DESIGN MAJOR/STUDIO: A HANDS-ON WORKSHOP FOR CREATING/TRANSFORMING AN INTEGRATIVE DESIGN EXPERIENCE

*Atsushi Akera, David Banks, Audrey Bennett, Ron Eglash, Michael Lachney, James Malazita,, Dean Nieusma, Tom Haley
Rensselaer Polytechnic Institute*

RPI's Programs in Design and Innovation (PDI) offers RPI students an opportunity to create dual degree programs typically built around an engineering degree and our social-sciences based Design, Innovation and Society (DIS) degree program. Going beyond a typical industrial engineering or product design program, we have created a program structure that introduces students to an array of social-sciences inspired skill-sets ranging from ethnography, cultural critique, problem formulation, social and environmental impact assessment, and stakeholder analysis. Through an integrated sequence of six design studios, plus a capstone design experience, PDI takes an integrated approach for students to develop aesthetic sensibilities, design identities, a sense of normative engagement, and strong identification with their student cohort.

During this year's Symposium, we will organize a hands-on workshop on making and re-making specific aspects of any design-based degree program, course, or experience that integrates engineering and liberal arts perspectives. Whether or not you are currently in the process of creating or revising such a course or program, we invite you to join us in a collective design and redesign effort.

We will do so through two sessions (45 minutes each) with breakout groups devoted to some or all of following tentatively proposed topics:

Session 1

- A Focus on Normative Engagement
- Engineering Design Processes and Their Critical Deconstruction
- Design * Theory

Session 2

- Reflections on Design Identities
- Building Mentors Into the Program/Classroom
- A Perspective on Users

Reporting Out

- Some time to report out & reflect on the experience

ABSTRACTS

MAKING AND LIBERAL STUDIES IN ENGINEERING

DIANE MICHELFELDER, MACALESTER COLLEGE

LOUIS L. BUCCIARELLI, MIT

Moving through and settling in all sectors of higher education at a rapid clip, the “making” movement supports many values of a liberal education, including creative inquiry, self-motivated learning, learning about how one learns, the joy of constructing tangible objects. But along with these creative, cognitive, and meta-cognitive benefits come a number of questions, especially the question: What is fundamental? How can the learning that occurs in makerspaces inform what a student must know, and the capabilities that he or she must possess, to function as an engineer? How can identifying as a “maker” translate into identifying as an “engineer”? These are the questions that should be addressed when planning making activities for engineering students to do, even when what they do is done informally and not for credit. We argue that it is not enough to attend to the technology alone – how to make it accessible to students, open to manipulation and sculpting to their purpose – while ignoring the social as well as instrumental ingredients and fundamentals of engineering making in practice.

Optimally, the making experience should be an occasion for “critical making,” an opportunity for reflection on the value systems inherent in entrepreneurial design. Critical reflection is another hallmark characteristic of learning in liberal arts. The authors will describe how the liberal arts can provide a home for a pre-professional degree program Liberal Studies in Engineering. In particular, they will explore how the so-called 3-2 or dual degree option offered by so many liberal arts colleges might be revitalized via Liberal Studies in Engineering with making as a key ingredient.

GOING FROM DESIGNING THE ENGINEERING EDUCATION OF THE 21ST CENTURY TO MAKING IT A REALITY: NATIONAL NETWORK FOR UNDERSTANDING AND ACCELERATING TRANSFORMATION IN ENGINEERING EDUCATION

**FATMA MILI, SORIN MATEI, MICHAEL CUNNING, ROBERT HERRICK
PURDUE UNIVERSITY**

The persistence, magnitude, and diversity of voices raising concerns about the state of engineering education and the need for drastic changes signal that the time has come to re-examine the very foundations of this key educational system in our society. Numerous efforts and initia-

tives to reform and fine-tune the system have proven insufficient and ineffective. Deep-seeded problems persist. The mis-alignments between today's – and tomorrow's – demands and the current system are much deeper than can be corrected by isolated efforts of curricular change or the adoption of new pedagogies. On the other hand, comprehensive efforts, when initiated, are quickly thwarted by a highly resilient and intricately interdependent educational system with a high capacity to revert back to the status-quo and squash all efforts that may deviate from it.

There is a growing number of mostly faculty-driven initiatives around the country and the world attempting to research and create alternative forward looking exemplars of engineering education. These exemplars are ambitious, innovative, and far-reaching in their potential impact. Because these initiatives represent potential challenges to the status-quo, most of them encounter systemic difficulties that take them by surprise and end up consuming much of their energy and resources. Leading such change efforts in isolation can be discouraging. The problem is compounded by two factors:

1. Since many of these transformative efforts are relatively new, there are few documented precedents that can serve as useful resources or guides;
2. The skill set and experience needed to navigate these systemic challenges are not typically in the repertoire of higher education faculty.

We are in the process of formalizing and seeking funding for an international network. In this workshop, we would like to share our motivation, progress, invite others to join, and work together at fine-tuning the scope and agenda for the network.

MODELING LIBERAL ARTS AND ENGINEERING INTEGRATION IN A NEW DEGREE

CHELL ROBERTS
UNIVERSITY OF SAN DIEGO

The University of San Diego (USD) is a liberal arts university. While there have been engineering programs at USD for many years, we recently created a new school of engineering. Prior to becoming a school, we had three accredited engineering programs. All of the engineering students take a minimum of 147 semester credit hours and receive a dual degree: BS/BA Engineering. The large number of credit hours allows our students to have the breadth of a liberal arts degree while also experience a deep engineering curriculum. We do have some examples of integration of the liberal arts and engineering including a successful living and learning communities in the early years across the university, some rich study abroad experiences that integrate engineering and liberal arts in an international context, and integrated undergraduate

research experiences. However, the majority of engineering courses and experiences are not integrated. We have found it challenging to innovate within the existing engineering curricula. This seems to be consistent with the literature on engineering curricular innovation.

To address this, we have been approved to create a new degree from a clean slate. The intention is to create the new degree to model a high degree of integration between liberal arts and engineering. We see this as a skunk works approach to innovation. The intent is that the newly modeled curricula and courses will be adopted by the existing disciplinary degrees overtime.

The focus of my proposed presentation at the conference would be to:

1. Share our perspective of engineering epistemology and how it relates to our approach in engineering and liberal arts integration.
2. Share our existing integration successes.
3. Share our current new degree model and some of the courses that model liberal arts integration in engineering.

THE ENGINEERING GRAND CHALLENGES AT A LIBERAL ARTS UNIVERSITY

JAMES VAN FLEET

BUCKNELL UNIVERSITY

Bucknell University identifies itself as “a unique national university where liberal arts and professional programs complement each other.” Bucknell’s university-wide Educational Goals have been adopted as the learning goals of the whole College of Engineering and all degree programs within the College. The specific learning outcomes required by ABET have been mapped to these learning goals.

In 2013, Bucknell launched an effort to participate in the Grand Challenges program of the National Academy of Engineering (NAE). This program identifies 14 Grand Challenges of Engineering and urges universities to establish Grand Challenge Scholars Programs (GCSP) to encourage and equip students to tackle these broad societal challenges. To develop and oversee our GCSP an internal steering committee was formed, consisting of deans, faculty, and staff from across the university. The University Library & Information Technology Department, Career Development Center, and Office of Civic Engagement are represented.

Grand Challenges Scholars are required to complete five program components; interdisciplinary coursework, research, entrepreneurship, service learning, and global activities. In 2014, Bucknell GCSP students participated in the Society and Technology Residential College, and took a first year Foundation Seminar course, normally required for students in the College of Arts & Sciences. In accordance with NAE guidelines, Scholars at Bucknell will complete a curriculum that prepares them to “work at the boundary between engineering and non-engineering disciplines.”

Bucknell offers many global experiences and service learning opportunities, including a study abroad summer program in Entrepreneurship and Renewable Energy, community service projects in New Orleans, the Nicaragua Bucknell Brigade, and a “Bucknell in Washington DC” program.

The Grand Challenges Scholars program at Bucknell University is emerging as a successful model, integrated with the University Mission, Educational Goals, and academic and service learning programs across the colleges, with diverse faculty, staff, and students participating in this effort.

EDUCATING FOR INNOVATION: TRAINING ENGINEERS IN CREATIVE PROBLEM SOLVING

R. DAVID KENT

MILWAUKEE SCHOOL OF ENGINEERING

We all want to graduate engineering students who are innovative thinkers and creative problem solvers. However, the standard engineering curriculum leaves little room for cultivating the creative ability of students. Required courses in engineering, math and science crowd out courses and experiences that could develop students’ creativity. At the Milwaukee School of Engineering, we are revising our general education core courses in a way that intentionally focuses on cultivating students’ creative abilities. The centerpiece is a series of three thematically linked courses that students are required to take during their freshman year. These courses focus on one or more of the engineering “grand challenges” or on what are sometimes regarded as “wicked problems.” These courses will be taught not just by our humanities and social science professors but by faculty in our engineering, science and business departments as well. In fact, some sections of the course will be team taught, giving students the opportunity to benefit from seeing how faculty from different disciplines approach creative problem solving. All three courses are communication intensive classes by design and will be run as seminars. In addition, we are incorporating a service learning component into this first year curriculum, so students are engaged in creative problem solving in a real-life context. Finally, we are embedding the freshman courses within the larger context of a comprehensive “first year experience” designed to introduce students to these social issues and to their roles as innovative thinkers even before they take their first class and throughout their entire freshman year. Altogether, we are confident that we are creating a holistic experience that will make students innovative thinkers and creative problem solvers.

DIGITAL SHORT COURSES FOR MULTIDISCIPLINARY ENGINEERING EDUCATION

**ALEX DALE, ENGINEERS FOR SUSTAINABLE WORLD
ERIN LENNOX, RENSSELAER POLYTECHNIC INSTITUTE**

In an effort to improve access to education on both skills and multidisciplinary topics within sustainability Engineers for a Sustainable World (ESW) has been piloting a series of digital short courses. Departing from the established Massively Open Online Course (MOOC) model, we have focused on small courses taught live and with a high degree of interactivity as part of course content. Topics at the time of this submission include Life-Cycle Assessment, Ecological Economics for Scientists and Engineers, and Introduction to Wicked Problems in Sustainability. Participants include students and professionals from around North America, and registration is open to all.

We plan to present the successes and weaknesses of the course program so far, highlighting differences with the MOOC model as well as areas where our work could be improved. We have found a strong interest in sustainability skills from professionals, and a stronger interest in more abstract concepts from students. Identifying an appropriate technology platform is key, but a minimal approach can be as effective as a robust but hard-to-access system for student engagement. Charging a nominal fee for courses does decrease total registrations, but significantly increases the percentage of registrants that attend the course. We hope to leave participants with an understanding of an alternative model for digital education and prompt discussion of new topics for short courses both within ESW and created by participants.

MAKING THE MAKER FAIRE FAIR: THE DIFFICULTIES OF MANAGING ACADEMIC INSTRUCTIONAL AND ASSESSMENT NEEDS WITH INTERDISCIPLINARY PROJECT-BASED LEARNING, WHILE ALSO MANAGING COMPLEX NON-UNIVERSITY PARTNERSHIP EXPECTATIONS AND REAL-WORLD PROJECT PRODUCTION

**DAVID GILLETTE, MICHAEL HAUNGS, JANE LEHR, ELIZABETH LOWHAM
CALIFORNIA POLYTECHNIC STATE UNIVERSITY**

In 2012, the Liberal Arts and Engineering Studies program at Cal Poly (San Luis Obispo), and the Center for Expressive Technologies (CET) were asked to collaborate with a local art museum, the mayor's office, local businesses, and an emerging "maker community" to produce the first-ever Mini-Maker Faire for the San Luis Obispo community. This seemed to be a perfect "real-world" learning project for the programs. Maker fairs appear to be an ideal joining point between studies in engineering and liberal arts. Producing this first Maker Faire for the city also

seemed like it would be of great social and educational benefit to the local community. What could go wrong? Plenty, especially when the need for high-quality academic instruction, course delivery and learning assessment came into direct conflict with the political and organizational needs of a city putting on its first major technology-arts festival. Academic needs quickly took a back door to the immediate, unavoidable issues of resolving complex financial issues; resolving political issues of project ownership, responsibility, and health and safety concerns; and resolving labor issues for building and running a large, day-long festival held at the historical center of the city. Our LAES program worked with the Maker Faire process for two years (2013–2014), and CET for three, each year both programs struggled in different ways to reconcile the academic needs of the university with the social/political needs of the community. Our presentation reviews this process of discovery, experimentation, failure, success, and resolution, while also noting how many of the specific issues of our Maker Faire collaboration are similar to issues many interdisciplinary programs face when connecting real-world, community-based projects to effective project-based learning, especially when also trying to combine studies in Engineering with those in Liberal Arts.

KNOWING WHO KNOWS: TEACHING ASSISTANTS AS LEARNING BROKERS IN ENGINEERING EDUCATION

**MICHAEL LACHNEY & DAVID BANKS,
RENSSELAER POLYTECHNIC INSTITUTE**

Engineering education research continues to reveal the importance of cultural responsiveness when preparing students for real-world problem solving. Undergraduate engineering curriculums however, continue to present problem solving skills and design methods as universally viable across cultural contexts. The result is that many well-intentioned engineering students, once they are asked to complete capstone projects, overlook cultural elements or have difficulty effectively utilizing their engineering skill sets in community contexts.

This paper offers an interventionist approach to culturally responsive engineering education based on the idea that teaching assistants (TAs) can be learning brokers who help students and faculty create real-world problem identification and solving scenarios that foster community-classroom connections. Based on our experiences as TAs for the Product Design and Innovation (PDI) program at Rensselaer Polytechnic Institute, we highlight the successes and challenges of our own roles as TA learning brokers. PDI studio classes are meant to infuse traditional design and engineering pedagogy with the kinds of critical engagements that are the foundation of science and technology studies. Including guest speakers and ethnographic research projects in our courses, we helped students explore the wide range of standpoints with regard to design, tech-

nology, and organizational logic. In so doing we ran into our own set of institutional and cultural barriers that encourage more traditional engineering curriculums that, while frustrating, elicit productive tensions that are worth theorizing.

First, we compare the role of TAs as learning brokers to traditional conceptions of TAs in higher education. Second, we contextualize our own interventions by comparing our studio classes that cover different subjects and offer examples of culturally responsive engineering design projects appropriate for a variety of design and engineering programs. Finally, we outline the institutional barriers found in traditional engineering education that, if TAs are going to take on roles as learning brokers, must be overcome.

DISCOVERY LAB – A SPACE FOR ELECTRICAL EXTRACURRICULAR PROJECTS

**JIM HEDRICK
UNION COLLEGE**

For several years the ECE department has received requests from engineering students for a place with electronic parts, hand tools, and test equipment to work on projects that are not connected to any formal course. In response to this request I have developed what we, at Union, are calling the “Discovery Lab”. The name was chosen to reflect the lab’s purpose of developing a lifelong love of learning in our students. The student’s projects allow them to apply material presented in classes and explore new concepts on their own. As the Discovery Lab has grown, there have been requests from liberal arts students to work on projects in the lab. Some of these projects have been connected with a formal course and some have not, but they have all had an electronics aspect. In some cases the facilities needed by these students are not available in their home departments. The Discovery Lab is student driven and as a result collaborations have resulted between engineering and liberal arts students that have benefited both. In addition to the space and equipment provided, I am available to help with technical questions, which may be beyond the student’s experience.

This talk will highlight projects completed in the discovery lab by engineering and liberal arts students, the equipment currently available in the lab, and the lab management structure we have developed.

MAKING ON THE MARGINS: POSSIBILITIES FOR MAKING AND HACKING AS INFORMED BY FEMINIST CRITIQUE AND STS

ELLEN FOSTER

RENSELAER POLYTECHNIC INSTITUTE

The excitement around the ‘Maker movement’ and its possibilities for economic, educational and innovation development are well-placed. The White House recently declared June 18th the National Day of Making, the Maker Education Initiative is working to bring maker practices to schools, and libraries are also looking to initiate their own maker labs. But despite a goal of inclusiveness, implicit barriers in terms of gender, race and class perpetuate in hackerspaces and makerspaces alike. Meanwhile, overarching making and hacking practices often fail to critically reflect on how their innovations answer: for whom, by whom and for what purpose? Delineating these failings, several scholars point to hegemonic norms that shape maker cultures and often reinforce consumerist trends and dominant practices in technology development and use (Morozov 2012; Nascimento 2014). What this paper seeks to tease out of this top-down, and often corporate, discourse, are on-the-ground activities that subvert the dominant rhetoric, questioning a lack of politics by actively reflecting on accessibility, situated learning, and situated knowledges. Analyzing these actions through a feminist lens (D.E. Smith; Haraway; Toupin) questions also arise around the valuation of some forms of labor and production over others. Taking from Michel de Certeau’s work on everyday life actions as tactics, this paper explores particular communities within the ‘Maker movement’, such as Fixers, Feminist hackers and makerspaces situated in libraries, that are employing humanities, social science, and political-economy critique. How are these particular groups examining and further producing marginalized knowledges that could contribute in positive ways to making, design, engineering, and education writ large? Pushing forward how might Science and Technology Studies and a critical arts practice further contribute, inform, and shape maker activities with the recognition that artifacts and the structural mechanisms that produce them do indeed have politics?

MATERIALS THINKING

ULRIKE G.K. WEGST, AYAN AZMAT, ANDREW L. BEAUBIEN, AMARIS A. DE LA ROSA-MORENO, MACKENZIE L. CARLSON, KEVIN R. BARON
DARTMOUTH COLLEGE

Currently under construction at the Thayer School of Engineering at Dartmouth is a “please touch” Materials Library that aims to excite students and visitors for materials science and engineering and enables training in Materials Thinking. It is designed to link software-based materials selection with physical samples, both in the form of bulk materials and products made from these. The goal is to assess and explore materials with all senses and to integrate rigor with intu-

ition. The steadily growing collection of physical materials examples started with 100 frequently used representatives of all classes, i.e. metals, ceramics, polymers and composites, which also include natural materials. The bulk material collection is complemented by typical products made from these to illustrate how specific materials are used and why. A software tool developed by undergraduate research assistants links technical information with images of both the bulk material samples and products (barcoded for automatic identification). Additionally, the software tool provides information for commercial sources and manufacturers from which the different materials can be obtained for use in the Thayer's Machine Shop. First use of the Materials Library in courses and outreach activities shows that it is a resource that not only greatly benefits students, who are taking materials-related engineering courses at Thayer, but generally members of the Liberal Arts community of Dartmouth ranging from Chemistry to Studio Art and Theater, and from Architecture to Computer Science and Music, thus all who share an interest in materials and wish to better understand, design and apply them. The presence of a highly diverse user group validates this resource as one that is ideally suited for a liberal arts education. The Materials Library is emerging as a significant contribution to the spirit of experiential learning and interdisciplinary cross-fertilization.

TREASURE WILD DUCKS...BECAUSE THEY CONTRIBUTE TO DESIGNING AND MAKING!

MOLLY STEVENS

IBM

On July 25, 2013, IBM CEO, Ginni Rometty, hosted a webcast to introduce IBM's 9 practices. One such practice that is fundamental to IBM's culture is to "treasure wild ducks," or ideas that might initially sound strange. In a large corporation such as IBM, employees come from a variety of backgrounds and possess differing perspectives. As a result, team mates may offer ideas that are unconventional and seem to be truly "wild." Yet, IBMers treasure wild ducks and advocate working environments that celebrate diversity, innovation, and original thinking.

In order to foster a creative working environment, a group of managers at the IBM Poughkeepsie, NY site launched a Wild Ducks pilot program in the summer of 2014. Participants were given ten minutes to "pitch" an idea that might improve a process, fix a problem, or boost employee morale. The audience, which consisted of an organization of about one hundred IBMers, was then given five minutes to ask questions, provide feedback, and contribute suggestions.

By the end of the Wild Ducks pilot program, it became apparent that these presentations were extremely successful in promoting innovation and multi-disciplinary collaboration. This presentation will highlight some of the benefits that the organization has received from treasuring wild

ducks and how the creative ideas that resulted from the pilot program have enabled IBMers to become better “designers and makers.”

DOES STUDYING MUSIC ENHANCE HIGHER ORDER LEARNING SKILLS IN UNDERGRADUATE NON-MUSIC MAJORS?

**KATHRYN EVANS, FRANK DUFOUR, ROSANNA GUADAGNO, AND
ROGER MALINA
UT DALLAS**

Many studies have looked at the correlation between music study and academic skills. A review of over 11,000 studies between 1950 and 1990 conducted by Harvard Project Zero tested the claim that studying the arts leads to some form of academic improvement. Only three areas were found that demonstrated a clear causal link between education in an art form and achievement in a non-arts, academic area. Two were in music: a medium-size causal relationship between listening to music and spatial-temporal reasoning and a large causal relationship between learning to make music and spatial-temporal reasoning. (Winner 2001). The majority of these studies have been conducted with students in primary and secondary education, but little research has been done on students at the undergraduate college level who study music, either as a minor or for general interest. Most pedagogical studies in music address the needs of music majors and not non-majors.

This pilot study looked at students at the University of Texas at Dallas who enrolled in music studies (either performance, theory or sound design) who are not majoring in music. Many are students in the STEM (Science, Technology, Engineering and Mathematics) areas. Through phenomenological research methods, we looked at the experiences of students who study music or sound design and how they perceive it affects their academic skills in other areas. Emails for students currently enrolled in music or sound design courses in AY2014-15 were obtained and they were solicited to take an on-line survey, with an option to volunteer for an in-depth interview. Over 800 students were solicited in February 2015 and a response rate of 20% has already been obtained. Additionally, over 30 students have volunteered for the in-depth interview. Initial data and a preliminary analysis will be presented.

INTEGRATING SOCIO-HISTORY INTO AN INTRODUCTORY INTERNATIONAL BUSINESS COURSE

RAFAEL BURGOS-MIRABAL

UNIVERSITY OF MASSACHUSETTS-AMHERST

Training in the business and management (B&M) professions presents similar pedagogical challenges to training in engineering. Traditionally, B&M education is conceived of as technical training for developing professional competence toward gaining employment. Ordinarily, the historical underpinnings of B&M disciplinary formation, the constitution of the traditional curriculum, and the broad societal effects that the deployment of B&M education and practices have, still remain far from integrated and examined into most present-day B&M curricula. In this presentation, I wish to describe my experience in designing, implementing, and evaluating an undergraduate introductory course to international business (IB). Instead of following the traditional content facilitation from the conventional IB syllabus only, I decided to split the facilitation into three class components: (1) an IB strategy simulation which ran through the entire semester; (2) team-based coverage of the mainstream approach to the IB subject matter, which ran through the first half of the semester (“IB 1.0”); and (3) team-based co-facilitated coverage of critically contextualized approaches (“IB 2.0”) to the IB subject matter to which we had already been exposed during the first half of the semester. The course was conducted in a team-based learning classroom, and each one of the three components revolved around team-based tasks. I will also discuss assessment methods for each one of the three components. Although I wish to share my experiences with the audience, my presentational goal and emphasis would be to motivate a dialogue about the pedagogical, institutional, and socio-technical challenges and contradictions that my innovative intervention met in its first iteration, vis-à-vis any experiences that members in the audience share in engaging professionally-oriented content and students in their own institutional and curricular contexts.

TEACHING AT THE INTERSECTION OF ENGINEERING AND THE LIBERAL ARTS

PETER WESTIN, BEN LAUGELLI, DOULGASS REED, W. BERNARD CARLSON
UNIVERSITY OF VIRGINIA

The University of Virginia’s School of Engineering and Applied Sciences (SEAS) requires all first-year students to enroll in an introductory course in the Department of Engineering and Society titled “Science, Technology, and Contemporary Issues.” There, students learn about the social context in which the work of the engineer takes place as they cultivate oral and written communication skills critical to their professional development. One of the unique challenges in

teaching the course is to orient its content and assignments toward the learning needs of engineering students and not students of the humanities in general. To accomplish this goal, we focus the course on great inventions that changed the world and offer lab sections that give students practical experience with invention.

In lectures students not only learn about historically important inventions but also the complex interaction of new technologies with the social context in which they were developed and used. To complement the theme of great inventions, labs give students firsthand experience with new technologies. For example, as students learn of celestial navigation technologies associated with Prince Henry, in lab they build a rudimentary inclinometer and use it to calculate the height of a flagpole on campus. Likewise, the major assignments in the course integrate the focus on technological inventions with the professionalization of future engineers. Throughout the semester students keep an idea notebook like those used by Thomas Edison. Students then orally present ideas to a small group of their peers. From there the group selects one idea and writes a provisional patent application that includes a technical description and an argument why their idea is more useful than similar patented technologies.

ENGINEERING DESIGN: A TECHNOLOGY TEACHER'S PERSPECTIVE

MELISSA HIRT

ALBANY PUBLIC SCHOOLS

The goal of this paper is to popularize engineering design pedagogy in New York State technology education. In New York State, technology education has the potential to engage students in the liberal arts tenets of hands-on and minds-on activities that explore problem solving, engineering design, and topics that range from the history of technology to manufacturing. For instance, students may engage in hands-on activities around egg drop containers, which involves the engineering design staples of building and testing their products while also working through highly collaborative and creative design processes. Yet, an emphasis on engineering design has been an evolving theme in technology education. This paper will explore the historical change in New York State schools from industrial arts education to technology education, and how these changes allowed educators to engage engineering design as part of teaching and learning with technology in their classrooms.

The paper will define what engineering design has looked like in the past as part of industrial arts education and what it looks like today as part of the hands-on and minds-on activities of technology education by asking the question: What is the meaning of engineering design in hands-on and minds-on technology classrooms? To begin, I will define what hands-on and

minds-on activities look like in the context of engineering design. Next, I will draw on examples from my middle school technology classroom to describe some best practices for integrating engineering design into technology education. Finally, I will describe a number of institutional and cultural barriers for integrating engineering design into my hands-on and minds-on oriented technology classroom.

ENVIRONMENTAL FORENSICS: A CONDUIT TO TEACH SCIENCE, ENGINEERING, ETHICS, LAW, POLICY, ECONOMICS, AND SUSTAINABILITY

**ASHRAF GHALY
UNION COLLEGE**

Environmental forensics is a rich topic that encompasses many scientific as well as non-scientific fields. These include science, engineering, ethics, law, insurance, society, litigation, policy, economics, pollution/contamination, cleanup, testing, standards, and sustainability. This interesting mixture of subjects provides a fertile ground for an interdisciplinary course. Sources of environmental problems are usually related to emissions, pollution, contamination, and/or waste disposal. Whether the cause is intentional or non-intentional, natural factors or a man-made disaster, or due to normal operation or accident, a crisis ensues and cleanup becomes necessary. This inevitably leads to legal actions and litigation that rely on experts in conducting scientific investigations to establish the facts surrounding potential controversies. Some of the pivotal questions related to environmental forensics investigations include: who caused the contamination, when did the contamination occur, how did the contamination occur, was it accidental or a series of routine operating releases, how extensive is the contamination, is there evidence of neglect or fraud, what levels of contamination have people been exposed to, can environmental forensics assist in allocating remediation costs, and most importantly, who will pay for the cleanup effort. To answer these questions one needs to discuss topics such as liability, site history, environmental site assessment, insurance litigation, toxic torts, science tools, sampling, statistical analysis, chemical fingerprinting, contaminant transport models, evidence evaluation, risk assessment, and expert testimony. This interdisciplinary course made extensive use of case studies to illustrate the goal of studying the above subjects. Students were asked to write two position papers on cases that have already been settled in court to express their opinion regarding the outcomes of the cases. In addition, students were also required to write and present a paper on an actual legal case of their choice that involved litigation founded in forensics. This course served educational and investigative goals.

REDEFINING LIBERAL EDUCATION FOR THE 21ST CENTURY

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inspired by tradition.**

Founded in 1795, Union College was the first college chartered by the Board of Regents of the State of New York. We are a small, independent liberal arts college committed to integrating the humanities and social sciences with science and engineering in new and exciting ways. Union's rigorous academics take place in a diverse, welcoming campus environment that supports your personal growth, provides you with a wealth of opportunities to find and pursue your passions, and inspires you to engage with the local and global community through meaningful projects and volunteer work.

At Union, you will find a vibrant community of learners and scholars, of leaders and change agents—people whose ambition, energy and desire to make things happen are contagious. The intellectual and creative spark can be felt in our academic buildings, Minerva Houses, labs, library, studios and recital rooms—anywhere you go on our historic campus. We have a long tradition of innovation and of educating creative problem-solvers, a tradition which continues to flourish and to define who we are today.

On the back cover: The Union College Logo (top) and Seal of Minerva (bottom). The adoption of the Seal of Minerva at the College's founding was a radical innovation in that it incorporated a French motto: "*Sous le lois de Minerve nous devenons tous freres*"—"We all become brothers under the laws of Minerva".

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