

Whitepaper for an
Illinois Foundry for Tech Vision and Leadership (iFoundry)
18 July 2007

Illinois's existing engineering and CS curricula were formed in the crucible of the cold war. Since that time, radical changes in transportation, communication, and computer technology leave us in a very different world. Books such as *The World is Flat* and *A Whole New Mind* suggest that returns to innovation and creativity are especially important in a world where routine analysis and engineering tasks can be outsourced globally for dimes on the dollar. Scientific discovery and the integration of technology in everyday life are occurring at an increasing rate, demanding a more direct involvement of engineers in leadership roles in business and public service.

Despite these transformational changes outside the university, engineering curriculum change within the academy comes incrementally if at all. If the United States is to continue its leadership in technological innovation and the creation, regulation and management of new technologies and new markets, its engineering force needs to be rejuvenated by a more diverse talent pool, where excellence in scientific education and analytical skills is complemented by a broader curriculum that inspires creativity and innovation and includes training in the professionalism and leadership traits needed for successful participation in the civic arena.

In response to the aforementioned opportunities and needs this whitepaper suggests the immediate establishment of a pilot program that brings together some of the largest undergraduate programs in the College of Engineering to effect necessary and realistic change in the undergraduate curriculum outside of the day-to-day workings of existing units.

In particular, the whitepaper recommends the creation of *iFoundry: The Illinois Foundry for Tech Vision and Leadership*, a unit in the College of Engineering aimed at maintaining engineering education in our university at the forefront of developments and trends in science, technology, and society.

The remainder outlines a number of key principles and attributes of iFoundry.

Key problem: Systemic difficulty of curriculum change. While there is growing understanding of the need to change, curriculum change within a unit is systemically difficult. First, untested changes with uncertain outcomes are proposed and compared to a certain and well-tested status quo. Second, every curriculum course and feature has at least some support among existing faculty members; thus, large numbers of substantial changes become politically intractable in the face of even large amounts of support for change. **Response:** Create separate pilot unit to pursue and test curriculum changes using volunteer students and faculty.

Key opportunity: Many contemplated changes cut across all CoE units. The National Academy of Engineering (NAE) reports on the Engineer of 2020, as well as

widespread discussion about engineering curriculum change, point to the importance of a variety of cross-cutting skills and disciplines: communications; leadership; teamwork; arts & design cross-fertilization; better utilization of humanities and social science hours; more general understanding of the societal and human contexts of engineering and technology. **Response:** Work collaboratively across the College to pilot new course work, collaborations, and themes and emphases that effectively incorporate these skills and disciplines.

The iFoundry idea: Both institutional and curriculum innovation for effective curriculum change.

iFoundry is conceived as a pilot unit of the College of Engineering to:

- (1) Overcome the systemic barriers listed above;
- (2) Exploit the collaborative opportunities for nation-leading change inherent in our times.

Specifically, faculty and students will be drawn from a small number of existing units and brought together under the rubric of the iFoundry unit, whose director will sit on the administrative committee of the College.

Students in iFoundry will receive degrees back in their home departments; however, curriculum modifications through iFoundry curricula themes and iFoundry sponsored courses will be permitted. Modifications will be permitted (variances) to existing curricula on a pilot basis (using Dean's signatory authority), and participating departments would grant degrees to students with iFoundry approved variances. Students in iFoundry who join to switch back to the regular curriculum of their unit, will be allowed to do so. In this case, iFoundry received credits will be applied toward electives in the regular curriculum (SS&H, Technical Electives, or Free Electives, as appropriate).

Existing unit heads, the Dean, and the Provost will join an iFoundry advisory board.

Keys: By having (1) a separate unit, (2) a mandate to pilot changes, and (3) tie-backs through actors from participating units, the changes tested in the pilot would transfer back to other units as they are proven in practice.

Innovative iFoundry Courses. iFoundry will foster the development of innovative engineering courses combining cross-disciplinary elements and/or themes (both technical and non-technical) related to emerging areas and trends. Courses developed and offered under the sponsorship of iFoundry can be utilized in existing curricula as a combination of technical and free electives. The existence of innovative iFoundry courses will motivate the traditional programs to modify their curricula to permit a larger number of electives.

Embedded social science & humanites, art & design, & business. Faculty outside the college will be enlisted to contribute to the development of new, cross-disciplinary iFoundry courses and to organize existing coursework from other campus units for iFoundry curricula.

The list of courses in Appendix A is presented as an incomplete list of existing courses with content relevant to the iFoundry objectives for curriculum enrichment. This list should not be interpreted as a set of courses to be used in their present form in the iFoundry curriculum. While such an option is possible following their content evaluation by iFoundry faculty, the main purpose of listing these courses is because of their potential use as a starting point for creating new course modules under the auspices of iFoundry, for use by different departments in different ways for enriching the breadth and interdisciplinary content of their curricula.

Respect for faculty governance. iFoundry will be a unit and will be governed by a set of bylaws with powers reserved for its director and faculty drawn from member departments. iFoundry courses will be evaluated by a faculty committee to identify their technical and non-technical contents (in equivalent hours). Curriculum changes fostered by iFoundry and proven successful through their pilot offering will be considered for integration in the regular engineering curriculum; however, these changes will not become part of a regular curriculum until they are vetted by the regular curriculum process in each home department on up the chain of command.

Interlaced commerce and entrepreneurship. Corporate sponsorship will be sought for the iFoundry effort and for members of the advisory board. Venture capitalists will be sought to help seed student entrepreneurial efforts and encourage venture formation by students as students. Representatives from key actors will sit on the iFoundry advisory board.

Embedded ABET and NAE influence. iFoundry will reach out to ABET to be involved with the program from the beginning, and will build on the NAE reports on the Engineer of 2020, and seek NAE input and feedback on the efforts as it continues.

Modern content and delivery orientation from the get go. Everything done in the program will be considered to be potential online content. Modules and materials will be available to traditional units as they are delivered for possible real-time incorporation into other curricula. Modules and materials will be available online to the outside world from the start.

Scalability a major consideration. Many pilots fail because they do not scale when resources are withdrawn. Every activity in iFoundry will be designed for sustainable and scalable delivery to a college with 5400 undergraduates. This requirement does not preclude experimentation on a smaller scale; however, provisions should generally be made for transferring the resulting coursework and materials back to a large undergraduate program economically and effectively.

Ongoing assessment. The pilot will be designed as an experimental program, and social scientists will gather data when appropriate and compare to extant programs. It might be possible to do comparisons to control groups in existing departments. It might also be possible to choose the iFoundry student body in an advantageous manner toward answering important empirical questions. Having said this, iFoundry recognizes

the importance of faculty individual decisions and judgment in the provision of effective curriculum changes. Assessments used by iFoundry can vary from intuitive informal assessment by individual faculty to involved statistical analyses of carefully designed experimental setups. The overall goal is the design and implementation of effective curriculum changes; thus, assessment is used appropriately to further that goal, not as an end in itself.

Pilot program duration and funding. There are a variety of ways to set the duration of the pilot program. To get through a single cycle of the undergraduate experience would require four years. To gauge hiring success of the first start-to-finish class would require an additional year (5 years total). To gauge the ability to draw corporate participation in and sponsorship of iFoundry activities would require an additional year (6 years total). To gauge the first stage of career success of the first full class would require a total of approximately 9 years. The duration of the pilot should be set in combination with these and budgetary considerations.

Although the pilot is imagined at first as a vehicle for undergraduate curriculum improvement, if it is successful, it may be a useful unit for continual improvement and innovation in graduate, undergraduate, and research initiatives in ways that are not fully anticipated at this time.

In addition to institutional support, iFoundry will aggressively pursue from its beginning a variety of outside sources of funding, including federal, private and corporate, to support its activities and engage with private industry and federal units in productive ways.

Space and organizational requirements. The pilot would require dedicated space over its life. iFoundry faculty and TAs will work together during the project life. Undergraduate advisory representation and Dean's signatory authority should reside in iFoundry to ensure that iFoundry students get degrees if they satisfy iFoundry pilot/experimental requirements. iFoundry classrooms should be fit with modern video/audio capture equipment and servers (modeled after Siebel), and iFoundry should have access to UIUC OCEE TV studios for production and post-production of course materials. The goal of these efforts should NOT be to create marginal revenue (at least at first). The goal should be to maximize influence of iFoundry experiments on NSF, NAE, ABET, and the larger engineering academic world.

Student body selection. The intent of the program is to pilot studies that will help create the engineering curricula of the future. Nonetheless, the program may be appealing to students as a "special" program, and it may be valuable to pilot the experiments with at least some of the students selected to be exceptional engineers of the future. For example, research on *tech visionaries* (TVs) at the UIUC suggests that creativity is an important dimension of the engineer of the future, and so it might be possible to select some of the students as meeting that criterion or other TV criteria, and some have suggested making iFoundry an honors unit during the bootstrap phase to help ensure its success. Having said this, as a pilot of the regular curriculum of the future, it is probably important to test the pilot classes on a regular cohort of UIUC

engineering students. In this way, perhaps it makes sense to construct half the student body from a regular cohort and half the student body from a TV-selected cohort with corresponding control groups in the regular engineering student population.

Immediate announcement and influence. iFoundry is envisioned as a response to a pressing and growing need for innovative changes in engineering curriculum of broader national and international relevance and interest. Truthful to the Illinois commitment to promoting innovation and improving the quality of life by responding to local, national and global societal needs, iFoundry will immediately embark on the mission to become a leading resource for others in their pursuit of engineering curriculum change, by sharing its whitepapers, presentations, and course materials with the larger world on a website available from day one. Powerpoints will be shared on services such as www.slideshare.net (see www.slideshare.net/deq511), course video will be shared on YouTube and Google Video.

Fall 2007 start is possible. The wrong way to launch this is to think about it over the next year, write plans, wring our hands, and worry. This will signal business as usual and a lack of urgency. The right way to launch this is to hold a fall one-day workshop and kickoff. On 5 September 2007, the College of Engineering is sponsoring a Workshop on the Engineer of the Future. This event could be used as a high profile way to kick off iFoundry or at least create greater awareness of it. It would take much of the fall to recruit and gather students for the spring 2008, but getting started sooner rather than later signals an uncharacteristic immediacy and importance that will itself have important symbolic impact.

Appendix A

Incomplete List of Campus Course/Curriculum Resources for iFoundry

Resources available. Faculty members in several departments have worked on courses and course materials that might be useful to the iFoundry mission to pilot new curriculum elements, arrangements, courses, modules, online resources, and other materials. The list given below is presented as an incomplete list of possible existing resources that can be useful to iFoundry. This list is not presented to suggest that all elements from all or any of these courses will be required in or even useful to iFoundry. It may be possible to recombine courses, extract modules, capture individual lectures, create useful course materials, and otherwise generate products to use for different departments in different ways as part of the iFoundry planning and implementation process.

Sample Resource Courses for iFoundry (iFoundry or ETSI faculty listed when appropriate)

ARNM 331 (Goggin), Image Studio
AVI 358 (Kirlik), Human Factors
AVI 456 (Kirlik), Human Performance and Engineering Psychology
ACCY 201, Accounting and Accountancy I
BADM 310, Management and Organizational Behavior
BADM 300, The Legal Environment of Business
BADM 320, Principles of Marketing
BADM 367, Management of Innovation and Technology
BADM 377, Project Management
CEE 417, Urban Transportation Planning
CEE 420, Construction Productivity
CEE 421, Construction Planning
CEE 422, Construction Cost Analysis
CS 210 (Woodbury), Ethical and Professional Issues in Computer Science
CS 498 (Karahalios), Social Computing
ECE 316 (Loui), Engineering Ethics
GE 361 (Price), Interpersonal Skills and Emotional Intelligence
GE 400, Engineering Law
GE 401, Patent Law and Related Topic
GE 461, Introduction to Tech Entrepreneurship
GE 498AA, Decision Analysis I
GE498TEE (Goldberg), The Entrepreneurial Engineer
GE 498MTV (Goldberg), Creative Modeling for Tech Visionaries
GE 541 (Vojak), Managing Advanced Technology
GE Online Shortcourse (Goldberg), Design of Innovation
HIST 364 (Hoddeson), Technology in Western Society (Lillian Hoddeson)
HIST 200F (Fouche), Engineering Change and Designing the Future

HIST 498 (Vostral), Science, Technology, and Gender
LIS 202, Social Aspects of Information Systems
NPRE 480, Topics in Energy Security
SOC 350, Technology and Society
SPCM 199 (Sandvig), [Communication Technology & Society](#)
SPCM 496 (Sandvig), [Play and Technology](#)
SPCM 496 (Sandvig), [Internet Law and Policy](#)

Appendix B

iFoundry: A View from the EE Undergraduate Curriculum

Erhan Kudeki

Department of Electrical & Computer Engineering

	EE curriculum		with iFoundry courses	
Semester 1	ENG 100	0	ENG 100	0
	CHEM 102	3	CHEM 102	3
	CHEM 103	1	CHEM 103	1
	MATH 221	4	MATH 221	4
	RHET 105	4	RHET 105	4
	SS&H	3	SS&H	3
Semester 2	ECE 110	4	ECE 110	4
	MATH 231	3	MATH 231	3
	PHYS 211	4	PHYS 211	4
	SS&H	3	SS&H	3
	Free Elec	3	Free Elec (iFoundry ?)	3
Semester 3	ECE 190	4	ECE 190	4
	MATH 241	4	MATH 241	4
	PHYS 212	4	PHYS 212	4
	SS&H	3	SS&H	3
	Free Elect	2	Free Elec (iFoundry ?)	2
Semester 4	ECE 210	4	ECE 210	4
	ECE 290	3	ECE 290	3
	MATH 386	4	MATH 386	4
	PHYS 213	2	PHYS 213	2
	PHYS 214	2	PHYS 214 (iFoundry)	2
Semester 5	ECE 329	3	ECE 329 (iFoundry)	3
	ECE 385	2	ECE 385	2
	ECE 313	3	ECE 313	3
	Tech Elec	3	Tech Elec (iFoundry ?)	3
	SS&H	3	SS&H	3
	Free Elec	3	Free Elec	3
Semester 6	ECE 440	3	ECE 440 (iFoundry)	3
	Adv ECE Elec	3	Adv ECE Elec	3
	Adv ECE Elec	3	Adv ECE Elec	3
	Tech Elec	4	Tech Elec (iFoundry ?)	4
	SS&H	3	SS&H	3
Semester 7	ECE 445	2	ECE 445	2
	Adv ECE Elec	3	Adv ECE Elec	3
	Tech Elec	4	Tech Elec	4
	Tech Elec	4	Tech Elec	4
	Tech Elec	3	Tech Elec (iFoundry ?)	3
Semester 8	Tech Elec	3	Tech Elec	3
	Tech Elec	3	Tech Elec	3
	Tech Elec	3	Tech Elec (iFoundry ?)	3
	SS&H	3	SS&H	3
	Free Elect	3	Free Elect	3
		128		128

The above table illustrates how courses developed as a part of **iFoundry initiative** can be accommodated in the existing structure of EE curriculum. Note that in the suggested program:

- 6 hrs of Free Electives (out of 11) are left untouched
- A total of 26 hrs of iFoundry courses are included some of which are taken as Tech Electives --- "tech hours" need to be justified and approved by ECE Curriculum Committee,
- PHYS 214 (2 hrs), ECE 329 (3 hrs), and ECE 440 (3 hr) are suggested to develop closely coordinated iFoundry versions which aim to provide a unified description (and applications) of particles and fields from classical as well as quantum mechanical perspectives,
- Tech Electives (iFoundry) hrs can be replaced (partially or in full) with Free Elective hours.

Appendix C

iFoundry: A View from the CEE Undergraduate Curriculum

David A. Lange

Department of Civil and Environmental Engineering

iFoundry is an initiative to improve the undergraduate experience, energize our program with new content, and deliver that content in new and exciting ways. The iFoundry program is driven by progressive themes in engineering education: invention, discovery, design & build, communication, entrepreneurship, globalization, history and public policy.

This proposal places iFoundry as a separate College program with unique course offerings. The iFoundry program coexists with department courses, but is not strongly integrated into department courses. The iFoundry program is emphasized in Freshman year (i.e. greater credit hours) with sustaining presence through all four years. The iFoundry program addresses topics that are relevant to all engineering disciplines, and will be attractive to students from all departments of the College.

The proposal strives to be realistic, and there are concessions to a variety of university, college, and department priorities, procedures, and rules. Among the assumptions made in this proposal are: Total credit hours cannot be changed; core departmental technical courses will not be changed; elective hours and the flexibility they represent are not sacrificed.

The proposed iFoundry program is 30 credit hours of coursework. The first year experience is unique and strong with 6 credit hours allocated to each semester. From the second to fourth years, iFoundry provides continuous presence through a series of 3 hour courses.

iFoundry courses must deliver authentic academic content. The iFoundry courses will teach computer skills, systems engineering, statistics and reliability, economics, communications, business skills, and history of science and engineering. The aforementioned topics are not separate courses, but are topics to be integrated into unique educational courses that combine active learning, hands-on experience, self-learning, experiments, independent library research, broad and compelling reading assignments, and provocative discussion. The proposal encourages an international travel component either during a summer or "Jan Term" period. Perhaps a summer course might be conceived, led by a faculty member, that takes the students overseas to study, for example, the history of engineered systems.

The feasibility of this proposal is tested by adapting the current program from the Department of Civil and Environmental Engineering. Figure 1 illustrates how the current CEE program can be changed to reserve 30 hours for iFoundry coursework. Courses eliminated from the current program represent content that is envisioned as central to the mission of the iFoundry program. For example, introductory computer programming, computer graphics and communications will be integrated into iFoundry courses. Only one of six Social Science and Humanities (SS&H) courses was given up, and no free elective hours were sacrificed.

A strength of this proposal is that it respects the tradition of the current program by not seeking an unrealistic level of overhaul of long-established technical courses. Nor does the proposal impact such a large number of courses that the costs of implementation would be prohibitive. The proposed iFoundry program does not conflict with fundamental university or college graduation requirements, and can be fully approved within the College and Department administrations.

	CURRENT		iFoundry	
	Course	Credit	Course	Credit
Semester 1	CHEM102	3	CHEM102	3
	CHEM103	1	CHEM103	1
	MATH221	4	MATH221	4
	SS&H	3		
	GE101	3		
	CEE195	0	CEE195	0
	ENG100	0	ENG100	0
			iFoundry	6
Semester 2	MATH225	2	MATH225	2
	MATH231	3	MATH231	3
	PHYS211	4	PHYS211	4
	CHEM104	3		
	CHEM105	1		
	RHET105	4		
			iFoundry	6
Semester 3	MATH241	4	MATH241	4
	PHYS212	4	PHYS212	4
	TAM211	3	TAM211	3
	CS101	3		
	SS&H	3	SS&H	3
			iFoundry	3
Semester 4	PHYS213	2	PHYS213	2
	TAM212	3	TAM212	3
	TAM251	3	TAM251	3
	PHYS214	2	BIOXXX (1)	4
	CEE201	3		
	CEE202	3	SS&H	3
			iFoundry	3
Semester 5	MATH385	3	MATH385	3
	TAM335	4	TAM335	4
	CEECORE 1	4	CEECORE 1	4
	CEECORE2	3	CEECORE2	3
	MBSE elec	3		
			iFoundry	3
Semester 6	CEECORE3	3	CEECORE3	3
	CEECORE4	3	CEECORE4	3
	CEEADV1	3	CEEADV1	3
	BTW261	3		
	MBSE elec	3	SS&H	3
SS&H	3	SS&H	3	
			iFoundry	3
Semester 7	CEECORE5	3	CEECORE5	3
	CEEADV2	3	CEEADV2	3
	CEEADV3	3	CEEADV3	3
	SS&H	3	SS&H	3
	SS&H (2)	3		
	Free elec	3	Free elec	3
CEE495	0	CEE495	0	
			iFoundry	3
Semester 8	CEEADV4	3	CEEADV4	3
	CEEADV5	3	CEEADV5	3
	CEEADV6	4	CEEADV6	4
	SS&H	3		
Free elec	3	Free elec	3	
			iFoundry	3
Eliminated (Pink) Courses		30		
iFoundry Program				30
Total		133		133

Notes:

1. CHEM104/5 replaced with BIO requirement in Semester 4
2. Move one SS&H from Sem7 to Sem4; move one SS&H from Sem8 to Sem6

Figure 1. Proposal for iFoundry Program based on CEE curriculum