Abstract—As the nature of engineering problems evolve at an ever quickening pace in an increasingly global marketplace; academic institutions are faced with strong and mounting pressures to adapt decades-old engineering education models in order to maintain their educational influence, relevance, and position with respect to students, industry, and the greater society. This transformation is especially challenging in the context of major research institutions with longstanding traditions of high quality engineering education. This paper presents a model for engineering education reform through an ongoing initiative within the College of Engineering at University of Illinois. Factors such as institutional resistance to transformation are considered and potential solutions are offered. The paper explores the power of pilot programs aimed at encouraging freshmen student involvement, development, and interaction. Consideration is given to implementation issues, and scalability within the context of the current pilot program. A focus on student leadership development and learning is presented within the program framework. Discussion of the role that upper level undergraduates and graduate students play in the operation of the program is also presented. Preliminary efficacy of the program and its future at the University of Illinois will be discussed. Upcoming challenges for the model will be considered with a primary focus on the challenges inherent in a program that relies heavily on student leadership and engagement. Concluding comments will be made regarding pilot programs as a vehicle for implementing engineering education transformation.

Index Terms—Engineering Education, Freshmen Experiences, Innovation, Student Community, Transformation, Well-Rounded Engineer

I. INTRODUCTION

Engineering as a profession has long played an important part in global history and development, often at the forefront of innovation and discovery. In contemporary society, the pace of innovation and change is rapid as globalization and technological advancement continue to revolutionize the world around us. Engineering plays a vital role in developing and utilizing this technology to improve a wide variety of aspects of daily life. As society’s sentries, translators, scouts, and guides to technology; engineers are vital to help society understand and utilize this technology to the fullest extent possible.

As technology moves to center-stage in all areas of global commerce and thought, so to should the engineering profession. In order for this transformation to occur, the mindset of engineering practitioners and educators must be broadened to reflect the greater influence and responsibility of the profession in light of technological advancement. Mainstream engineering education currently embodies an antiquated model of an engineer as a singular, static, technical instrument that plays a limited role in broader society. This engineer submits technical reports to decision makers but has little involvement in the actual decision making process at a societal level. With an ever increasing number of important decisions largely based upon technological foundations, society is left in an increasingly difficult position without the uniquely informed perspective offered by engineers. The mindset must be changed in educational institutions to teach young engineering students to embrace a model of engineers as an integral part of the decision making process through the development of inter-disciplinary skills, non-technical know-how, creative problem solving, and a mindset of constant innovation. This transformation will allow engineering to be used to more effectively help society solve some of its most pressing issues and problems.

II. ROADBLOCKS TO IMPLEMENTATION

There is emerging consensus within the engineering community that steps must be taken to improve on the current educational paradigm. This is exemplified in the US National Academy of Engineering’s Engineer of 2020 report as well as the subsequent volume Educating the Engineer of 2020 [1], [2]. Some of the reports’ recommendations include educating...
engineers to embrace life-long learning and requiring interdisciplinary components in academic programs to help better prepare students for today’s environment [2]. The NAE further recognizes the need for reinvention of engineering education to help to allow engineering to maintain and enhance its position to further societal goals.

While the broad outlines of educational reform have approached a consensus, little widespread change has been seen in many engineering programs throughout the United States. Institutional-level reluctance and resistance toward curricula reform is a major impediment to meaningful change in how engineers are educated. Much of this resistance stems from the democratic, departmental nature of curriculum change in higher education. Goldberg et al. report that much of this resistance is a direct result of faculty reluctance to change the portions of the curriculum that directly affect them, which they term academic not-in-my-backyard (NIMBY) [3]. The other major source of resistance according to Goldberg is the fact that curriculum change cannot be associated with data until after it is implemented. This makes empirical support of curriculum innovation proposals difficult and suggests the need for an alternative model to facilitate effective curriculum change [3].

III. REFORM FRAMEWORK
AT THE UNIVERSITY OF ILLINOIS

With an understanding of the institutional challenges inherent in curriculum change at the post-secondary level and a belief that transformational change was necessary to ensure that the next generation of engineers are prepared for success in today’s global environment, leaders within the University of Illinois began formulating an alternative to the traditional change efforts launched through the structure of departmental and college curriculum committees. Founded in 2007 under the leadership of Prof. D. Goldberg and Prof. A. Cangellaris, the Illinois Foundry for Innovation in Engineering Education (iFoundry) was envisioned as an inter-departmental programmatic-curriculum incubator within the College of Engineering [3]. As such, iFoundry’s mission is to pilot and test curriculum changes prior to adoption and implementation at the departmental and college levels.

IV. PILOT PROGRAM

Following the organizational and logistical legwork of 2007-2008, iFoundry introduced an innovative pilot program for freshmen students in the fall of 2009. This program was offered to all high school seniors applying to the University of Illinois (UI) through an additional application process separate from university admissions. 120 students completed the iFoundry application, which consisted of basic demographic information and an essay question designed to allow students to relate their interests, academic and personal aspirations, and reasons and rationale for wishing to participate in iFoundry. Very little information regarding the nature of the program was provided to the students beyond the over-arching goals of providing an innovative new approach to engineering education at the undergraduate level.

All students that completed the application process were invited to participate as part of the first class of iFoundry students. Of the 120 iFoundry applications received, approximately 100 students were admitted to the university and 88 accepted enrollment at the UI. Of these 88 students, 73 participated and have stayed engaged in the program through the fall and first half of the spring semester and are considered the first cohort of iFoundry students. This cohort represented all engineering departments within the college. In an engineering college as large as the UI, with a total undergraduate student population of approximately 6,000, the initial class was quite small. This small size allowed verification of the program concept and refinement of particular components ahead of expected scale up with future cohorts.

The iFoundry program is structured to allow student choice to be respected and creativity to be fostered as participants develop non-technical and inter-disciplinary skills. As the program does not represent a major curriculum change, little additional coursework was created beyond the existing requirements. A one hour graded course was created for all students within the cohort. Beyond this course, all additional program components were designed in such a way as to not disturb the current curriculum landscape. These program components were implemented through creative use of existing requirements and extensive reliance on extra-curricular activities supported through a network of students, faculty, alumni, and corporate partners.

A. Required Course Component

The graded course component of the initial iFoundry pilot program was a single credit hour course taken during the fall semester. The introduction of an additional one credit hour course into the existing curriculum did not represent a major change in existing practice. The course title “Introduction to the Missing Basics of Engineering: Preparing for a World of Work and Service in a Creative Era” illustrates the importance that iFoundry leadership placed upon the need to infuse non-technical skills into the engineering curriculum [4]. The Missing Basics course is designed to fill the requirement for an existing college-wide, no credit course that introduces students to the university. The existing course has traditionally been half-semester in length and taught solely by upperclassmen undergraduates within the college, called Engineering Learning Assistants (ELAs).

The new iFoundry course differs from the college-wide introductory course in that it complements general discussion of college life led by an ELA with philosophical and project-based work led by iFoundry faculty and staff. Qualitative critical and creative thinking have been demonstrated as crucial skills for contemporary engineers [5]. These skills are an important part of the iFoundry course and are called the missing basics. The missing basics and project-based learning form the backbone of the course and are a key component of the entire iFoundry experience [4]. Examples of these kinds of activities found within the course include the construction of a steam-powered car and discussions on Global Community, Diversity, and Inquiry [4]. The focus on early design experiences follows models currently in use at the Franklin W. Olin College in Massachusetts, USA. Further development of this theme is currently underway within
iFoundry for students as they move beyond their first semester through additional course pilots.

B. Utilizing Existing Course Requirements

Since the space within the curriculum for development of new courses was quite small and the relevance of any such course across such varied disciplines as Electrical Engineering and Bioengineering is a major design constraint, program leaders developed frameworks for students to develop their interests within the existing course structure. This also allowed choice and student-driven ideas to stay central to the development of course selection within the program.

One of the areas identified in the NAE reports [1], [2] and elsewhere as a challenge for current and future engineers is developing a broader understanding of the world beyond the technical details of engineering science so well taught within contemporary engineering curricula. While technical skills should and will remain a vital part of engineering education, depth and breadth of non-technical skills are important and emerging necessities that are not adequately addressed in current engineering education practice [6]. To help students develop non-technical skills, iFoundry created a program to encourage first-year students to think critically about non-technical interests and establish some level of non-technical depth using existing college and campus general education requirements. Traditional thought considers general education as a vehicle for instilling a wide breadth of knowledge to the student. Human Artifacts, Processes, and Interactions (HAPI) Themes provide opportunities for students to group non-technical general education coursework into coherent, relevant areas of study that provide elements of depth to general education beyond the traditional breadth.

While HAPI Themes are not mandatory, iFoundry staff and volunteers assist students with course planning related to non-technical courses and offer a partial listing of available themes and associated courses. To prepare for the first HAPI Theme year (2009-2010), sample theme ‘templates’ were developed around Economics, Philosophy, Understanding People, and many other areas. Students were encouraged to develop additional themes to meet their own interests and a methodology for recognition and approval of student-driven themes was developed and distributed.

With campus and college general education requirements totaling 12 hours (generally four courses), each HAPI theme is required to consist of 9 hrs (three courses) to give students some depth in their chosen area of study. While not mandatory, the documentation, support, and encouragement of students is designed to help them develop an understanding of the importance of non-technical courses and move students away from the traditional apathy of engineering students towards general education requirements. At the same time, these themes will allow students to dig deeper and take away a greater understanding of non-technical issues from the same physical number of courses as traditionally required.

A vital component of the HAPI Theme implementation was the utilization of upper-level undergraduate and graduate students to provide advising related to the themes. These students provide insight to the iFoundry cohort by relating their more recent experiences within the college and campus to the younger students and helping to match course offerings and opportunities to student passions and aspirations.

C. Extra-Curricular Components

While the course components of the iFoundry program are an important step towards changing engineering education within the University of Illinois, the extra-curricular components of the program are less constrained campus and college norms. As a result of this freedom, the extra-curricular component has been utilized as a tool to reach out and have a significant impact on students. This piece of the program has also opened up many opportunities for freshmen that were not previously available under the existing education system.

The extra-curricular component of iFoundry is founded on the concept of the iTimewa group of students clustered not by discipline but rather by broad, thematic, inter-disciplinary interests that were determined by the iFoundry leadership from students’ initial application essays. Students were then given the opportunity to choose from the different interest groups during the admitted student kick-off program held at the beginning of the semester. Each iTimewa consists of 10-25 students that work together to learn about their topic of interest and grow together in their understanding of engineering and its interactions with the rest of society. For the 2009 cohort, iTimewas were centered around the following four themes:

- Art and Engineering Design (AED) - the interface of engineering with art and industrial design in human centered and new product design.
- Engineers in Service to Society (ESS) - environmental, philanthropic, and broader impacts of engineering on societal fabric.
- Entrepreneurship and Innovation (EI) - engineering at the nexus of technology and business with a focus on innovation and new product development.
- Service and Systems Engineering (SSE) - technological services used to innovate and improve societal well-being through human-centric design and engineering.

Through weekly evening meetings teams were encouraged to develop an identity, explore projects related to their group, provide academic support to one another, engage with corporate contacts relevant to their field, and develop a social network with team members. Service projects were also encouraged for each team. The activities of each iTimewa were monitored regularly by iFoundry staff and critiqued at the mid-term point (iCheckpoint) and at the end of the semester (iEXPO). Both of these events were designed to allow students to develop presentation skills and served as a showcase for what each group was doing within their iTimewa.

The four iTimewas composed the entire cohort, which was grouped with the supporting faculty, staff, and student volunteers to form the iCommunity. The iCommunity was
defined as the place for individuals and teams to come to coordinate cross-group interactions and projects. Each iTeam was also required to elect a leader (iChair) who would serve as the primary contact between the group and the rest of the iFoundry organization.

At the initial kick-off event each student was provided a document outlining the basic structure and purpose of the iCommunity. There was no explicit set of instructions or requirements but rather a framework from which student groups could follow their own interests. This was designed to maximize student creativity and allow students to engage in problem formulation and definition from the very beginning of their university experience. A more complete reading regarding the iTeam and iCommunity structure can be found in [7].

V. REALIZING THE PROGRAM

The pilot structure composing the elements described above was created to advance the goals of transforming engineering education for the current millennium under the existing university constraints. As iFoundry organizationally is a curriculum incubator for the College of Engineering, this program served as a first step towards curriculum reform at the University of Illinois.

In order for the realization of the iFoundry vision in even a pilot form, a support network was required for the course and student community. This challenged the program to implement a support structure that was not only viable for the pilot program but could also be scaled to a larger student population and ultimately the entire freshman population at the UI. This required creative staffing of the various support functions required for the program components.

For the introductory course this was done by enlisting the support of a select group of the current student instructors (ELAs). Interested ELAs were recruited from the college-wide program to provide individual assistance to each section of the iFoundry course. They assisted in administrative work and provided guidance to student groups as they completed their projects. iFoundry-involved faculty rotated through the course, providing guest lectures on the topics most related to their individual interests and expertise. One instructor was also tasked with guiding all student sections through the project-based portion of the course.

The HAPI Theme creation was completed through a group of involved faculty and student volunteers with an interest in engineering education reform. This process was initiated in 2008 before entering students arrived on campus. This group developed templates that were compiled by iFoundry staff members who also assisted in advising students on non-technical course selection. Much of the advising was done by student advisors who came from a variety of backgrounds to assist and mentor the iFoundry cohort. Called iSAs, these students included graduate and undergraduate students and were paid on an hourly basis for their efforts. The structure of advising sessions with experienced students was less intimidating to students than the traditional faculty advising context, preserved faculty member’s time, and supplied a current mix of experience and advice to the students from experienced students as they began to consider the non-technical dimensions of their education.

The iCommunity and iTeam segment of the iFoundry program also hinged heavily on the involvement of iSAs in team activities. Each iTeam was assigned two iSAs who assisted the team members throughout each semester. They filled the role of mentor, coach, and resource for team members and helped guide the teams through the open-ended requirements of the program. The eight iSAs met regularly with iFoundry leadership and compared notes and best practices to better serve their teams. iSAs were recruited for both broad and team-specific qualities in order to be best able to guide and serve their respective team. In general, iSAs were active on campus and believed deeply in engineering education reform and the mission of iFoundry. They were excited about mentoring students and happy to share their knowledge and experiences and push students to consider broader impacts of their iTeam work.

In addition to the iSAs, iFoundry faculty and staff were active in formulating the iCommunity activities and guiding iCommunity evening meetings. The engagement provided by high-level faculty encouraged students and helped them to realize that they as students were the key piece of the iFoundry program. Open discussions between iFoundry leadership and iSAs provided a feedback loop that allowed all parties to stay abreast of recent student development.

Corporate and alumni involvement is also critical to the iFoundry model. This aspect allows students to get an early understanding of the ‘World of Work’ through contacts with iFoundry involved companies working in fields aligned to iTeam interests. This connection allowed for collaboration and advice on student projects and gave students a feel for the ultimate outcome of their engineering education.

VI. ACTIVE STUDENT LEADERSHIP

One of the keys of the iFoundry freshman program was student engagement and leadership within the cohort. The iTeams were student directed and run with assistance from the iFoundry leadership, student advisors, and corporate partners. This allowed the students to take ownership of their team and cater their projects and activities to team member interests. This student driven focus is a primary differentiating feature between the iFoundry program and many other freshman engineering programs. The structure of the team allowed students to lead their peers from the outset of their college experience. This is in marked contrast to both the typical engineering classroom where students are generally passively receiving information and student extracurricular organizations where leadership is often based on seniority.

Each student team elected an iChair who was the coordinator and leader of the team for the semester. Leadership opportunities for the students extended beyond the iChair as teams broke down their tasks and activities such that different individuals took lead roles in different areas. Some of these specialties included corporate relations, social activities, and service work. Cross-communication between
teams was encouraged and iChairs met to discuss iCommunity issues and opportunities on a regular basis.

To support the student-centered learning fostered through the course and the iCommunity, iFoundry placed an emphasis on utilizing current student leaders as guides and mentors to the teams. It was important for these ELAs and iSAs to support the student community without leading their respective student teams. In practice this often meant that the student advisors worked closely with the iChairs to ensure that they were making progress towards their team’s stated goals and offered leadership advice and suggestions to the team leadership.

Beyond leadership within the context of the student-led iTMs, iFoundry also encouraged broader leadership within the cohort by embracing an attitude of ‘go for it’ with respect to student ideas and goals. When individuals or groups of students approached the student advisors or leadership with a suggestion for an event or activity, they were supported and encouraged to pursue these interests. This further encouraged student creativity by giving them space to explore ideas and receive feedback from experienced students, faculty, and staff on how to achieve their goals.

VII. STUDENT ADVISORS

In order to realize the iFoundry freshman program, student support from within the College and the cohort itself was crucial. The ELAs, iSAs, and student volunteers provided an integral piece of the organizational structure. While student taught courses are nothing new at the undergraduate level, the manner of engagement between the faculty, student employees, and student cohort within the program provides a new lens from which to approach student-faculty relationships. This is especially true for the iSAs, who not only worked directly with the iFoundry leadership on defining the extracurricular component of the program but also were the primary point of contact between the student leadership and the program. The iCommunity format further provided a different context for freshmen student leaders to interact with experienced engaged upperclassmen and graduate students beyond the typical hierarchical extracurricular environments and the graduate teaching assistant-student relationship that is common in introductory courses. This provided a low pressure environment where student to student institutional knowledge and experience could be transferred on a large scale.

The initial selection of iSAs for the program was provided by the iFoundry leadership from a pool of students engaged in early stage development and learning associated with the program. This model worked well for the initial small pilot but is not practicable for full scale implementation. The current iSA group has taken charge of developing and implementing selection and hiring criteria for future year’s student advisors. This process resulted in intense discussions regarding the goals and requirements for student advisors for the iCommunity. A critical piece of this discussion involved the experience and skill set of the prospective student advisor.

Several key tradeoffs emerged from this discussion. The first of these was encountered when discussing the matching of iSA skill strengths to iTM goals and aspirations. While a student leader with similar skill sets to the student aspirations will be best able to mentor student projects and provide detailed knowledge regarding the aspiration, he/she may be less able to provide a holistic view of student engagement. On the other hand, an iSA with a richer variety of experience and background could provide a deeper context for the freshmen in his/her group to build upon their interests in a multi-faceted, interdisciplinary way. These iSAs may have lower perceived relevance to their team and might not be as well suited to the teams’ aspirations. The ability to mentor and provide guidance without active team leadership is critically important trait of iSAs regardless of subject matching or breadth in order to facilitate the iTM as an avenue for freshmen leadership development.

VIII. PRELIMINARY STUDENT OUTCOMES

The iFoundry pilot program is designed as a first step towards a more innovative and responsive engineering curriculum for the 21st century. Of primary importance is developing student perspectives and skills that are better aligned with the global, integrated world graduates will enter following commencement. Furthermore, the program attempts to help students find the joy of engineering through creative design work at the beginning of the curriculum. Developing and maintaining a passion for engineering in young students is critical in improving student success at the university level. Current curriculum does not adequately accomplish either of these goals. For students who arrive at the university with a passion for engineering through building things and developing ideas, the first several years of intensive math and science coursework leaves little room for creativity and learning what it means ‘to engineer.’ For these students, much of the passion for engineering has been beaten out of them prior to their emersion in higher-level design courses.

For students that chose the engineering curriculum for other reasons, such as excellence in math and science at the high school level, the current paradigm does no better. The first few years fail to show these students the ultimate outcomes of their work and efforts and leave very little space to develop an engineering ‘sense.’ In either case, without some infusion of the art and joy of engineering and a view of ultimate outcomes, the difficult concepts and high workload contribute to lack of student persistence. By giving students a collaborative community with a large degree of self-direction, iFoundry enables exploration and learning around the joys of engineering. By adding an introductory design experiences at the freshman level based in large degree to the model currently in practice at the Franklin W. Olin College, the program gives students both a better idea of what engineers do and provides a creative outlet for their ideas and passions.

The abilities of first year engineering students is often overlooked and assumed non-existent in contemporary programs. This pilot study allows students space to show their abilities and learn from each others’ backgrounds in a controlled design environment in both the iCommunity and within the course. Providing this space to students gives them ownership over part of their education and helps connect them to the curriculum as a whole. Allowing students to use skills they developed before entering engineering school broadens
their concept of engineering and encourages a more holistic view of the profession.

Interdisciplinary work is evidenced within the iFoundry framework through both the coursework and iCommunity components. As both course sections and iTMs are composed of students across disciplines, numerous opportunities for interdisciplinary collaboration are an integral part of the iFoundry concept. The connections made between students and iFoundry faculty members also offer a foundation for students to collaborate with faculty in research and other areas as they progress through the university. This interaction also provides iFoundry students with a comfort level in dealing with faculty members that is generally not seen in freshmen students.

Initially the majority of the students involved in the program were uneasy with the lack of prescriptive rules and requirements within the iCommunity. Many voiced concerns that they were not being given enough direction at the kick-off meeting and in the weeks that followed. Other groups created rules and boxes within which they chose to work in. For instance, every group reached the conclusion that the ultimate deliverable from the iTM was a completed project by the end of the semester and they each developed plans to reach that goal in accordance with their own group aspirations. Contrary to their assumptions, this was never an action required by the iFoundry program. Much of the iSAs’ effort during the first semester was spent steering teams away from this initial project fixation.

As the semester concluded, student outlooks and beliefs began to change. Realizing that the lack of rules was not an ill-defined problem given by the leadership but rather an invitation to run with whatever ideas a group had, students began to blossom creatively. While all kept some elements of a project as part of a unifying mission for their group, the teams began to use their teams to explore collective interests. For instance, members of the Entrepreneurship and Innovation used the iFoundry platform to attend an innovation conference hosted in California to expand their understanding of the subject while members of the Art and Engineering Design took a field trip to the Chicago office of Skidmore, Owings, and Merrill to observe life in a design office.

More remarkably, by the end of the semester, the freshmen were appreciative of the lack of direction given at the outset of the semester. The revelation that the initial ambiguity was intentional and had educational value to the program became a major portion of student presentations at the end of the year iEXPO that showcased team achievements.

IX. MEASUREMENT METRICS

As in any early stage study, meaningful quantitative measures of student success within the iFoundry program are difficult to come by. iFoundry students are currently in the midst of their second semester of freshmen year, so even first year retention statistics cannot be utilized to get a picture of the effectiveness of the program. The full program impact cannot be measured until graduation for even this initial cohort of students.

In spite of the difficulty of obtaining measurement data regarding the success of the program that can be immediately analyzed, data is actively being gathered for later analysis by the iFoundry leadership. Much of this data is qualitative and the current focus of research in this area is centered around student attitudes towards the program and how they evolved over time. Especially important is exit interview data that is being compiled from those students who chose to leave the program after the start of the semester. This data will ultimately be used to determine what motivations for leaving iFoundry students currently have and how these motivations should be addressed within the program.

Further studies are needed to ensure that quality data is also gathered from the rest of the iFoundry students as they progress through the program. Qualitative data should be supplemented with survey instruments as well as retention and grade point data to determine the effectiveness of the program. Conclusions drawn from any data on this small pilot study must not be immediately assumed to be valid for the college as a whole. Especially since the cohort was self-selected, the impact of the program on the entire freshman class may be different from that of the self-selected sample. Increasing the cohort size will provide better data but conclusive efficacy data will not be available until full-scale implementation is achieved.

X. IFOUNDRY BEYOND THE FRESHMAN YEAR

As iFoundry completes its introductory semester, questions remain about the role of the organization in student development throughout the college experience. This continues to be a work in progress as the program adapts to the feedback and needs of the students and university. As students progress past the transition from high school to college, many of the program aspects critical for success in the first semester take on diminished importance. As students utilize the connections formed within the iTMs to branch into other student organizations, the extra-curricular opportunities provided by the program become less important. Departmental communities develop as students move into discipline-oriented coursework, lessening the need for the community provided by the program.

Different aspects of the iFoundry program become more important as the cohort moves beyond their initial semester. Interactions with corporations take on an increased role as students navigate opportunities for internships and co-op programs. One of the primary foci of the iCommunity in the second semester is the ‘World of Work.’ As part of this program, students are exposed to a multitude of different career opportunities through lectures from a wide variety of professionals and continued interaction with the iFoundry corporate sponsor contacts.

Coursework reform is also critical to the continued success of the iFoundry cohort. In keeping with the iFoundry mission of respect for faculty governance, courses are currently being piloted to iFoundry students within the college to determine the efficacy of different models of engineering education. For instance, this spring brings the first pilot course in user-oriented design offered in partnership with the Franklin W. Olin College at the UI. This course gives students an interdisciplinary look at design beyond the typical engineering curriculum.
The iSA network also continues to be available to students as they progress into new challenges and continue beyond the freshman year. The role of the iSAs has become less active and will continue to be so as the students’ progress and mature. iSAs’ roles towards continuing students become more defined by mentoring than direct, active guidance.

As an open question to a program in progress, a complete answer to how the program follows students to graduation and beyond is still unclear. The goal of the program is to continue to provide avenues for students to maximize their educational opportunities at the University of Illinois. As a pilot program, the ultimate goal is adoption by the College of Engineering for the full entering freshman class. With that transition, the program will become part of the overall engineering curriculum and the pilot program concept for curriculum change will be validated.

XI. FUTURE LARGE-SCALE IMPLEMENTATION

The impressive impact that the iFoundry program has made upon the student participants has prompted attention from the college as a whole. This interest culminated in the spring of 2010 with the announcement that the iFoundry freshmen program will be expanded and adopted by the College of Engineering as the Illinois Engineering Freshman Experience (iEFX). This program will reach 300 students for the fall 2010 class, approximately ¼ of the freshmen students entering engineering at the University of Illinois. This scale up will allow more students to experience the benefits of the iFoundry program and help to validate the program with a larger student sample. The hallmarks of the new program will be the same as the iFoundry experience of 2009, and the administrative structure will be similar. The 300 students will again be self-selected from an application process that can be accessed by students following their acceptance to the University. With college support, many of the innovations in the freshman experience can be institutionalized and formalized such that eventually all students can experience the iFoundry program.

Scalability remains a major concern of both the college and within iFoundry. The scale up to 300 students will be a major step and a test for the existing model and certain modifications may result from the resulting scale. One such change that is certain is the lessening of the personal touch evident in the first year of the iFoundry experience. With a small group of faculty, students, and student advisors; communication could be direct and it was easy for all involved to discuss the message to stay on the same page. With scale-up, much of the personal connections between the students and iFoundry leadership may be lost. Procedures are currently being developed to ensure that community and accessibility are maintained with larger numbers of students.

Part of the solution to this problem is the enlistment of the support of departments within the college more heavily than was done for the pilot program. This reliance will give needed instructors to teach the iFoundry freshman course and integrate departments more fully into the iFoundry enterprise. Another facet of the solution is the enhanced use of upper-level undergraduates and graduate students to fill more teaching and mentoring roles. The current iSA ranks will be expanded and the possibility of utilizing TAs to deliver more course content is also under evaluation. Finding iSAs and other student facilitators (TAs, ELAs, etc.) will be complicated by the requirement that these students to embrace the iFoundry vision for innovative, transformational engineering education. Finding enough experienced students motivated to help young students with an ability to guide these students through open-ended self-defined challenges will be increasingly difficult as the program increases in size.

As iEFX grows and the college takes ownership of this specific program, iFoundry as an organization can again look at the curriculum and identify other weak spots in the within it that can be addressed through piloted, grassroots change. This will ultimately help to address the future of upper level student’s involvement with respect to iFoundry. As an incubator of innovation in engineering education, iFoundry will be able to focus its resources on beginning another successful change to engineering curriculum.

XII. FUTURE CHALLENGES

While the initial pilot has produced significant, positive results, challenges remain in the program’s future and decisions about the program’s nature during scale-up will shape its long term character. The organizational nature of the program is allowing an organic, results-based growth and acceptance rather than expansion by college or university fiat. As the pilot program has shown success in improving student outcomes, departments have been given the opportunity to request greater numbers of students in the program. Each interested department is asked to provide a faculty advisor (iFA) for each additional 25 students they wish to enroll in the program. This is resulting in the significant expansion described above with contributions from both the departments and the college. This cost-sharing and outcomes-based expansion is a vital piece of ensuring that the program is sustainable within the college as it increases in size.

One significant challenge is how to approach the intermediate sized cohort prior to college-wide implementation. While the initial pilot was not selective of incoming students applying for the program, better publicized intermediate steps supported by departments may draw more students than the program is equipped to handle. This may result in the imposition of selectivity onto the application process. While selection would not be based on academic credentials but rather holistic measures to gauge student interest and fit within the program, a selective program raises some tensions. Once choices are made about choosing students for the program, the open, grassroots nature of the program is threatened. Vigilance is needed to ensure that the universal nature of the transformation is kept and the program does not become another ‘special program’ within the college.

Another interesting challenge has been observed in discussions regarding selection of future student advisors for the program. While the initial student leadership team was involved in the broader iFoundry initiative somewhat prior to the first cohort entering the college, including preliminary development of HAPI themes and a fact-finding trip to the Franklin W. Olin College during the Engineer of the Future 2.0 Conference, they did not mature within the iFoundry
community during their first years at the college. Instead, student leaders came from a wide variety of backgrounds and had unique perspectives derived from these backgrounds. As iFoundry alumni increase in prevalence within the college as the program matures and scales, a natural tendency towards self-selection may develop when choosing future student advisors. While the advantages of understanding the iFoundry ideal is important for student advisors, a broad range of backgrounds and experiences provides a better foundation for mentoring and coaching the student led iTeams. A mixture of sources for student advisors should be maintained in order for the richness of the student to student relationships between advisors and the cohort to continue at their current high level.

XIII. Conclusion

Engineering education reform is critically needed in today’s global context yet is difficult to realize given the realities of higher education institutions. By working outside the traditional college power structures, iFoundry has been able to pilot a successful program that changes the nature of undergraduate engineering education at the freshmen level to align better with the collaborative, creative world of contemporary engineering. By embracing and supporting student creativity and ingenuity, the program has been able to have a transformational effect on students with minimal changes to the engineering curriculum. By encouraging departmental support coupled to positive pilot results, the program has enabled scale-up and long term viability. As the program is ongoing, all conclusions are preliminary, but the positive outcomes on students are clear from initial data. The program has been successful at the pilot stage and current work involves an intermediate scale-up to capture more incoming freshmen. Important developments include the College of Engineering’s embrace and assumption of ownership of the program.

The initial success of this program demonstrates the power of pilot programs as vehicles for initiating engineering education transformation at a large research university.

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References

Engineering Education Reform at Illinois: Strategies and Reflections on Innovation

Brian Schertz, David Goldberg, and Karen Hyman
Transforming Engineering Education Conference
Dublin, Ireland
Thursday April 8th, 2009

Motivation and Background

Baseline Assumption: We wouldn’t be here if we believed that innovation was unneeded.

Several differences amongst TEE Attendees include:
• What the critical changes that need to be made?
• How we should go about making these changes?

Shared understanding that change is difficult.
Challenges to Curricula Innovation

Change efforts often share:
• Resistance by Curriculum Committees
• Lack of operational/organizational support at many levels:
  – Individual Faculty Members
  – Departmental Organizations
  – College and University Structures

Common themes heard throughout the conference

Our Perspective

• How can challenges to implementation be mitigated?
  – Don’t challenge governance/curricula committees
  – Respect departmental choice

• But isn’t changing the curriculum the whole idea?
  YES BUT...
  – A frontal assault isn’t always the best attack

• Our general conception of education may be too narrow
  – A broader definition allows a flanking maneuver around the domain of curriculum committees
Pilot Freshman Program

Key Functional Components:
• Introductory Course
  — ‘The Missing Basics’
• General Education Thematic Grouping
  — ‘HAPI Themes’
• Extra-curricular Community
  — ‘iTeams’ and ‘iCommunity’
• Industry Engagement
  — ‘World of Work’

Additional Course Requirement: One Semester Hour

Introductory iFoundry Course

Fall 2009 Content:
• ‘Missing Basics’
• College 101
• Inter-disciplinary laboratory/design component

What are the ‘Missing Basics’?
• Skills beyond math, science, and engineering science critical for engineering
  — eg. Philosophy, Design, Communication, etc.
‘HAPI Themes’

HAPI = Human Artifacts, Processes, and Interactions

• Thematic General Education Groups
• Voluntary, supported, and encouraged
  – Advising provided
• ‘Create-your-own’ theme **highly encouraged**

e.g.) Economics, Philosophy, Understanding People

Extra-curricular framework

Teams form basis for extra-curricular involvement
• Student leadership
  – Advice from faculty, staff, upper-level students, corporate contacts
• Weekly meetings
• Open structure encouraged:
  – Exploration of projects
  – Provide academic support
  – Interdisciplinary collaboration
  – Freshman student leadership
  – Social engagement
Student Community and Team Makeup

2009-2010 Student Teams:
- Art and Engineering Design
- Engineers in Service to Society
- Entrepreneurship and Innovation
- Service and Systems Engineering

Each team:
- 10-25 Students
- Corporate Contacts, Student Advisors, Faculty Advisors

Reporting and Results

- Groups reported progress mid-semester and end of semester
  - Group presentation skills developed
  - Open format allowing student creativity
    - Videos, presentations, songs all used
- Too early for conclusive outcome information
- Studies in progress
- Program generally well received by the cohort
Program Uniqueness and Strength

• Focus on extra-curricular component
• Pilot nature allows effectiveness to be demonstrated and support built upon success
• Reliance on student leadership
  – Also on student advising
• Respect of student aspirations and interests
• Providing space for students to explore and develop their learning
Future

Scalability: always a big concern
Fall 2009 – 73 students
Fall 2010 – 300 students

How?
• College of Engineering ownership
• Departmental Support and faculty involvement
• Student Led Communities
  — Both within the cohort and through student advisors, mentors, and TAs

Broader Implications

• Demonstrating success even at small scale builds support for change
• Space to allow students to explore interests in semi-structured way provides educational benefits
• Freshmen students have a large degree of skills and knowledge
  — This is an important part of keeping the passion for engineering alive during the first years of math, science, and engineering science curriculum
• Extra-curricular avenues allow earlier:
  — Student leadership
  — Connection to college and university extra-curricular organizations
The Engineer of the Future 3.0
Unleashing Student Engagement in Engineering Education

University of Illinois at Urbana/Champaign
November 14-15, 2010

Questions and Discussion

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