AC 2012-4902: WORKING COLLABORATIVELY AMONG UNIVERSITIES: A DENSE NETWORK APPROACH

Prof. Cynthia C. Fry, Baylor University

Cynthia C. Fry is a Senior Lecturer of computer science and Assistant Dean of the School of Engineering and Computer Science, Baylor University.

Dr. Sridhar S. Condoor, Saint Louis University

Sridhar Condoor is a professor in the Aerospace and Mechanical Engineering Department. He is also the Program Director for Mechanical Engineering, a KEEN fellow, a Coleman Fellow, and the Editor of the Journal of Engineering Entrepreneurship. Condoor teaches sustainability, product design, and entrepreneurship. His research interests are in the areas of design theory and methodology, technology entrepreneurship, and sustainability. He is spearheading Technology Entrepreneurship education at SLU via Innovation to Product (I2P), iChallenge, and entrepreneurship competitions and funded research. He is the Principal Investigator for the KEEN Entrepreneurship Program Development Grants to foster the spirit of innovation in all engineering students. Condoor authored several books. The titles include Innovative Conceptual Design, Engineering Statics, and Modeling with ProEngineer. He published several technical papers on topics focused on conceptual design, design principles, cognitive science as applied to design, and design education. VayuWind, a hubless wind turbine for urban environments, is one of his inventions. VayuWind deploys airfoils parallel to the rotational axis in such a way that, unlike other windmills, it rotates around a ring frame, leaving the central portion open for other uses. This enables VayuWind to extract wind power using existing structures such as commercial buildings and skywalks with minimal noise pollution.

Dr. Timothy J. Kriewall, Kern Family Foundation

Timothy J. Kriewall leads the Kern Entrepreneurship Education Network (KEEN) Program at the Kern Family Foundation located in Waukesha, Wis. Prior to this role, he served as President of Wisconsin Lutheran College in Milwaukee, a position he held for five years. He began his career at Bell Telephone Laboratories where, with a colleague, he helped develop one of the world’s first computer-aided circuit board layout programs deploying interactive computer graphics. Subsequently, he served in various capacities at 3M and Medtronic corporations, focusing on the invention and commercialization of innovative medical devices. Among the products Kriewall helped commercialize were the first cochlear implant to receive FDA approval and a patented state-of-the-art heart-lung machine based on controller-area-network logic. Kriewall also served as a professor in the Department of Obstetrics and Gynecology at the University of Michigan Medical School for eight years, earning the rank of Associate Professor, focusing his research in perinatal medicine to quantitatively understand the forces of labor and delivery on the newborn. He has been in his present position since July, 2008. He is a life member of IEEE, a member of ASEE, and a Fellow in the American Institute of Medical and Biological Engineers.

Dr. Christopher Kitts, Santa Clara University

Christopher Kitts is the Robert W. Peters Professor in mechanical engineering at Santa Clara University where he serves as Director of the Robotic Systems Laboratory. Kitts runs an aggressive field robotics program focused on the design and operational control of robotic systems ranging from underwater robots to spacecraft. As part of this activity, Kitts serves as the Mission Operations Director for a series of NASA spacecraft, as an affiliate researcher at the Monterey Bay Aquarium Research Institute, and as a KEEN Fellow for Santa Clara’s program in undergraduate innovation and entrepreneurship education. Kitts’ previous experience includes service as a satellite constellation mission controller in the U.S. Air Force, as a technical contractor for NASA Ames Research Center, and as a DoD Research Fellow at the U.S. Philips Laboratory. He holds degrees from Princeton University, the University of Colorado, and Stanford University.

©American Society for Engineering Education, 2012
In “To Change the World: The Irony, Tragedy, and Possibility of Christianity in the Late Modern World,” author James Davison Hunter espouses the idea that the engine for driving change in virtually any context is in dense networks. According to Hunter, a dense network is defined as a mechanism for change. According to Sarah Miller Caldicott, grand niece of Thomas Edison and the Founder/CEO of Power Patterns of Innovation, “A dense network includes a handful of key components including a passionate focus, diverse skills and competencies related to the passionate focus, a robust outreach network, the desire to disrupt unneeded orthodoxies in core institutions, and – perhaps most importantly – an inspirational leader.”

In the past year this paradigm of collaboration has been applied in the academy in two specific instances. Schools from the Kern Entrepreneurship Education Network (KEEN) have formed two such networks, each with the intention of accelerating growth in the area of promoting an entrepreneurial mindset among all engineering students, and for the purpose of using these networks to better benefit students and change the institutional culture at the institutions involved. One network, which has members from six different universities, was formed to promote and spread innovative approaches to entrepreneurial education. The other network, comprised of four other universities, will work collaboratively to create engineering graduates who are world changers and who direct projects that change the world.

This paper will document the design, development, and early implementation of these two dense networks, including the challenges faced throughout these phases, lessons learned, and early assessment results.

Introduction

The KEEN Network

The Kern Entrepreneurship Education Network, or KEEN, is a consortium of 21 private universities and colleges located across the United States that are committed to working together to change engineering education in the United States. Incepted in 2005, the mission of the Kern Entrepreneurship Education Network (KEEN) is to graduate engineers equipped with an entrepreneurial mindset who will contribute to business success and in so doing, transform the U.S. workforce. Through their synergistic cooperation, the graduates of KEEN colleges will be better prepared to keep America in its economic leadership position in the world. The schools are passionate about instilling the entrepreneurial mindset in 100% of their graduates, currently nearly 19,000 students in total, without the specific intent of necessarily creating entrepreneurs. Instead, the engineering colleges will be creating engineers who know how to leverage technology to benefit people around the world.

Through this special breed of engineers, new and existing technologies will be exploited to create products with high worldwide demand. As a result, American jobs will be created, and America will export more value-added products than they import. More American jobs will give
employees the joy and sense of purpose that comes through work, the opportunity to own homes, to raise families and to send their children to college. America’s freedom, liberties and standard of living will be maintained and improved. This audacious vision was given to us by our Kern Family Foundation founders, Mr. and Mrs. Robert Kern.

The private colleges and universities that are working together to accomplish the KEEN mission are:

- Baylor University (TX)
- Boston University (MA)
- Bucknell University (PA)*
- Gonzaga University (WA)
- Kettering University (MI)
- Lawrence Technological University (MI)
- Mercer University (GA)
- Milwaukee School of Engineering (WI)
- Ohio Northern University (OH)
- Saint Louis University (MO)
- Santa Clara University (CA)
- Union College (NY)*
- University of Dayton (OH)
- University of Detroit Mercy (MI)
- Illinois Institute of Technology (IL)
- University of Evansville (IN)
- University of New Haven (CT)*
- Villanova University (PA)
- Western New England University (MA)*
- Widener University (PA)*
- Worcester Polytechnic Institute (MA)

*Colleges that entered the KEEN Network in 2011.

In his book *To Change the World*, author James Davison Hunter asserts cultures are changed from the top down and center out through networks of institutions that define the terms and frame the issues of culture change. He defines three types of networks: vertical, horizontal and dense.\(^1\) Kern Family Foundation program staff members were made aware of the book well after the KEEN Network of private colleges and universities was formed. Hunter learned of the KEEN Network well after he wrote his book. Yet, KEEN could easily be a case study for the book. In the following, an explanation will be given regarding the three kinds of networks and how they function.

**Vertical Networks** – Within the scope of KEEN, vertical networks are those groups of institutional offices within each university from the top of the organization to the bottom committed to instilling the entrepreneurial mindset in 100% of its engineering undergraduates. Vertical networks include the president’s office, the provost and/or the VP of academic affair’s office, the engineering dean’s office, engineering department chairs’ offices, engineering faculty and supporting staff.\(^3\)

We have seen that vertical alignment within a school is necessary but not sufficient to change engineering pedagogy. We have cases of several schools such as Case Western Reserve University, Calvin College, Valparaiso, IIT and Marquette where faculty vehemently embraced the notions of the KEEN Theory of Change but their administration did not. The reasons varied such as overall university priorities (building/development /fundraising programs vs. educational programs), philosophy (research vs. undergraduate education), programmatic emphasis (engineering vs. arts and sciences emphasis) or basic unawareness by the administration. In some cases such as Bradley University, administrative support seemed to be enthusiastically present, but faculty conscription to KEEN precepts was dysfunctional at best. In all cases, without vertical alignment, KEEN floundered or failed to gain traction within the institution.
**Horizontal Networks** – Within the academy, no level of administration can mandate to faculty that any pursuit should be followed. The concepts of “faculty governance” and “academic freedom” preclude this possibility. That is why administration support for KEEN is necessary but not sufficient to have KEEN flourish on a campus. Horizontal networks across faculty ranks are required to dissolve organizational silos and get peer pressure to work in a positive way to effect change, just as Hunter describes in his book. These changes likely won’t take place in large public universities or even in private universities with large endowments. These institutions will be confident in their way of doing business and will resist making pedagogical change to an ABET-accredited engineering program.

For KEEN to flourish on any campus, faculty members are the change agents that need to personally embrace the KEEN Theory of Change. We have seen that faculty participation goes through several phases:

- They need to know *why* change is required,
- They need to know *what* change is required,
- They need to know *how* change is made,
- They need to know *when* the change is required.

Thus, faculty development is critical. Over the course of each year, KEEN meetings are essential to facilitate this process. They are:

- The January annual KEEN conference,
- The October annual principal and co-principal investigators’ meeting,
- The Shaping the Entrepreneurially Minded Engineer Workshops held two or three times each year,
- Regional meetings held on an *ad hoc* basis, and
- Faculty development workshops that individual campuses hold.

These meetings allow faculty and administration to learn from each other the best practices in making the changes required to expedite accomplishment according to the KEEN Theory of Change.
Dense Networks

Dense Networks of schools work closely together and are a special type of institutional horizontal network. They have multiple and frequent touch points geographically and throughout the year. One might say the schools could be considered “birds of a feather” in that they share common objectives and outcomes. They are dependent on one another, both in the work they do and the funding they receive from the Kern Family Foundation.

With the special insights provided by Hunter regarding the concept of dense networks, the KEEN Program Director approached the Foundation president and key board members in testing the notion of whether KEEN could create a novel dense-network funding strategy. The strategy would be that a group of three to six schools would come to the Foundation together to pitch a proposal that would show synergy between the schools. The condition of funding would be that all schools would be funded or none would be funded. This places responsibility of the more KEEN-mature institutions to bring along the newer, less mature universities to raise them to a level of quality that would deserve funding. Further, it would help the institutions identify their own core competencies that would benefit the other members in the dense network of schools.

March 11, 2011 will be remembered in the annals of KEEN as the day the first dense network of six schools came to the Foundation to pitch a multi-million-dollar grant request for the duration of three years. Each school requested a separate amount commensurate with their needs. This dense network named itself the Dynamic Compass Network or DCN for short. They were successful in garnering Foundation support. The DCN was comprised of:

- St. Louis University (lead institution),
- Boston University,
- Kettering University,
- Lawrence Technical Institute,
- Gonzaga University, and
- Worcester Polytechnic Institute.

Shortly thereafter another dense network of four schools formed and followed the process set by the DCN. This network called itself the Helping Hands Dense Network or HHDN. Interestingly, the original HHDN group had a fifth school, but members of four schools did not feel the fifth school was mature enough to contribute sufficiently to the dense network. In fact, it was the lack of a strong vertical network at the fifth school that precluded their participation.

The second dense network came to the Foundation on August 12, 2011 to successfully pitch their proposal for another multi-million-dollar grant request for a duration of three years. The HHDN is comprised of:

- Baylor University (lead university),
- University of Dayton,
- University of Detroit Mercy, and
- Villanova University.

Inasmuch as coordination against goals and timelines is essential, the dense networks of schools have agreed to publish and share with each other and the Foundation a one- to two-page monthly status report in the following format:
• Overall global objectives,
• Accomplishments against goals for the previous month,
• Deviations from plans,
• Critical issues, and
• Goals for the next month.

It is anticipated that this explosively collaborative approach to meeting the goal of instilling the entrepreneurial mindset into undergraduate engineering students will continue to evolve. At this time there are two more potential dense networks of KEEN institutes that are planning proposals for innovative and collaborative work, and multiple additions to the numerous dense webs (more on this under “Ancillary Activities”).

The next crucial step is to assess the effectiveness of this approach to collaboration. Assessment of the student learning objectives is critical, certainly, but so too is the assessment of how the KEEN is accomplishing its goals. All of this will provide a wealth of information on the effectiveness and efficiency of innovative and collaborative activities, where instead of competing against each other, institutions partner together, leveraging each other’s strengths and resources, to do something together that none could do by themselves.

**The Dynamic Compass Network (DCN)**

The Dynamic Compass Network (DCN) is a dense network composed of six KEEN institutions: St. Louis University (lead institution), Boston University, Kettering University, Lawrence Technical Institute, Gonzaga University, and Worcester Polytechnic Institute. It is the first KEEN dense network designed to take the KEEN initiatives to the next level performance in terms of:

• Helping to catalyze the promotion of the entrepreneurial mindset in students at multiple schools
• Fostering collaborative initiatives focused on student-centric pedagogy to strengthen individual as well as other DCN institutions

The Objectives of DCN are:

1. To transform the educational experience of undergraduate engineering students in order to develop the entrepreneurial mindset.
2. To change the culture of our faculty who are involved in the education of our undergraduate engineering students to enable the transformation of the students’ educational experience.
3. To provide the infrastructure to encourage, support, and facilitate intercollegiate entrepreneurial activities in the DCN and KEEN.

The six elements of the DCN are:

• **Curricular Innovation** – Synergistically innovate and implement a phased new teaching paradigm for e-mindset
- **Faculty Excellence** – Actively engage a community of scholarly faculty who collaboratively cultivate entrepreneurial mindset in students
- **Practitioners Community** – Provide a window of opportunity for students and faculty to access corporate and community leaders
- **Peer Collaboration** – Enrich the educational experience by providing new opportunities for students to exchange ideas/information/experiences both locally and across the Network
- **Continuous Improvement** – Use best practices to monitor progress towards KEEN goals
- **Experiential Learning** – Provide hands-on learning opportunities to students throughout the undergraduate program

The DCN was designed to rapidly create and pilot collaborative initiatives focused on the education of undergraduate engineering students, distill best practices through synergistic interaction of multiple schools, and share ‘best practices’ related to the incorporation of entrepreneurial mindset principles into the educational experiences. In short, the DCN will change the engineering educational paradigm through synergistic interaction between the DCN institutions.

**Formation:**

The Dynamic Compass Network formed in October 2010 at the KEEN Fall Conference as part of the Kern Family Foundation poster competition. “Enable the Trainer” and “Dense Network” with a concentric circle model focused around the students as the central element remain at the core as the unifying theme for the DCN from the beginning.
As with any team, the DCN went through the forming, storming, and norming process. As part of the forming phase, representatives from the six schools and the Kern Family Foundation met in Detroit in December 2010. The representatives spent the day answering the question “How do we create a deep engagement within the DCN to exploit new opportunities?” From that meeting, three project goals surfaced.

The storming phase consisted of DCN meetings in Tempe as part of the KEEN winter meetings and in St. Louis in January 2011. It was through these meetings that a collective outline describing the interaction of the DCN was developed. These meetings also led to the development of a collaboration model, an understanding of individual strengths and weaknesses, and aspirations associated with the DCN grant proposal. All the schools recognized and accepted that any “pain” associated with diverse collaborations would be far outweighed by the value associated with the Network.

The norming phase took place over the month of February. DCN members conducted bi-weekly conference calls to develop our collective proposal as well as to assist with the development of individual institutional elements. The norming phase included affirming our shared goals, developing an implementation plan for the Network, and finalizing the draft proposal you are currently reading.

The final phase of team building, performing, is where the DCN stands today. The relationships built over the past three months have left a strong dense network that is ready to perform by enacting the vision set forth in this proposal.

DCN made significant strides in its first year. Some tangible outcomes include:

a. Student boot camp on Innovation – Lawrence Tech hosted the first student boot camp in collaboration with the Ford Foundation.

b. Faculty enrichment workshops – Lawrence Tech hosted a workshop on the use of Problem-Based Learning (PBL) to incorporate the entrepreneurial mindset. Saint Louis University started the Innovating Curriculum with Entrepreneurial mindset (ICE) workshop. The workshop facilitated collaboration and exchange of material among 12 faculty.

c. Student activities include Innovation Encounter competition where the students from the KEEN schools participated in a one-day innovation challenge.

The Helping Hands Dense Network (HHDN)

The HHDN is the second dense network established and funded by the Kern Family Foundation, and is made up of four institutions: Baylor University, the University of Dayton, the University of Detroit Mercy, and Villanova University. In seeking to affect a positive change of culture in the way engineers are educated and in the world that will be shaped by these practicing engineers, the HHDN is guided by the following vision statement: The HHDN schools will work together to create engineering graduates who are world changers and who direct projects that change the world.
Objectives of the HHDN

The HHDN member institutions seek to create an improved learning environment for the students. Toward that end, the HHDN member institutions will tap the collective energies and skills of their various constituencies including faculty, students, alumni, and industry connections in support of the following objectives:

- Leverage industry ties to develop a deep understanding of intrapreneurship, develop collaborative **intrapreneurship end-to-end education (IE3)** curricula that will enrich the student learning experience
- Employ **intercollegiate student projects (ISP)** that are impactful and multi-disciplinary, with diverse student teams as a central element of an exciting new intrapreneurial culture

Formation

The HHDN followed the same sequence of *forming, storming, and norming*, that the DCN experienced. As part of the *forming* process, members of the HHDN met in conjunction with the 2011 KEEN Winter Conference in Tempe, Arizona, where member institutions developed an initial series of goals based on common institutional visions and the leveraging of each other’s strengths.

The *storming* phase began in earnest with the first Regional Conference, held at the University of Dayton, in March 2011, where 90% of the time was spent developing the vision, mission, and objectives of the HHDN. This first regional conference resulted in the development of seven objectives, all noteworthy and fully capable of furthering the initiatives of the KEEN:
One month later, however, at the second regional conference of the HHDN, held at Baylor University in April 2011, these seven objectives were combined into the two major objectives that now exist, where the focus of each is more clearly defined and understood. This was the major outcome of the HHDN’s norming phase of development.

Over the next several months the vision, mission, and objectives of the HHDN were more thoroughly thought out, detailed and higher-level project plans developed, and in-depth budgets were created. In addition, each of the individual institutions worked diligently to propose independent objectives that would continue the momentum built by past KEEN grants. All of these pieces were incorporated into a proposal, along with a letter signed by the presidents of all four institutions, and presented to the Foundation.

Relationship Assessment and Accountability

At this point in time, the HHDN has officially begun its performing stage. In fact, several sub-objectives of the proposal were begun in parallel with the final presentation, before funding had been received. Activities that were piloted in fall 2011:

- Two multi-school projects were piloted between the University of Dayton and Villanova University, with some lessons learned for the kickoff of the HHDN grant
- A kickoff meeting of the HHDN was held at Villanova University to more thoroughly develop the tasks and subtasks associated with the HHDN objectives
- Three of the four HHDN institutions were able to attend a SuperCoach four-day workshop at Baylor University in fulfillment of one of the sub-objectives of the end-to-end intrapreneurship education objective

A spring planning meeting of the HHDN was held in conjunction with the 2012 KEEN Winter Conference. The HHDN will meet in conjunction with other KEEN, ASEE, and related meetings at least four times a year, with bi-weekly teleconferences.

Corollary Activities Within the KEEN

Back in the poster competition activity held during the 2010 Fall KEEN Conference, one institution, Santa Clara University, was intentional about NOT joining explicitly with any number of their peers, but instead took an implicit approach to building what they call “dense webs” – overlapping and interacting dense networks, where instead of a network of distinct institutions, a web of collaborations can be formed with many, overlapping institutions:
The challenges involved in the development of dense webs are numerous:
- Coordination across locations and time zones
- Different goals and constraints that can cause conflict
- Multiple different collaborations

However, the benefits far outweigh the challenges:
- Build a stronger team with complementary core competencies
- Strong programs help to strengthen other universities
- Collaboration can start small and grow as best fits the goals and objectives of the institutions involved
- More efficient use of resources across the networked team
- Increased pool of talent from which to draw
- Leverage contacts of partners to identify new opportunities
- And so on…

Next Steps / Summary

It is important to note that formation of dense networks is contrary to the culture of higher education for the last 500 years. Inasmuch as it is a school’s singular value proposition to give its graduates its name (e.g., I graduated from…), the culture of universities has been to elevate its name and prestige above other schools. With the KEEN horizontal network of colleges, and with dense networks in particular, the goal is to help the other institutions in a sense to make a virtual campus. Thus, their graduates may claim a singular alma mater but also may claim to have worked with some of the best minds at the institutions in the network of schools. This alone distinguishes the graduate from other one-name-school graduates in the pursuit of employment in a competitive job market.

As importantly, the schools that form dense networks must learn how to work together as a team. This, too, is antithetical to higher education. Our experience in observing the formation of the two dense networks has been that they needed to go through the team-formation process of forming, storming and norming before they could reach the performing stage. Hunter may wish to publish an addendum to his book to highlight the importance of this process.
A standard has now been set in the year 2011 that puts pressure on the remaining schools in the network to form a dense network rather than approach the Foundation for a one-school grant. This, the Foundation staff feels, will accelerate the rate of change in creating a new breed of engineering graduate.

---

3 “Office” includes everyone within the office such as vice-presidents, associates, assistants and staff.
5 “Dense Webs and EEEs: Building Interactive Dense Networks Based on “Entrepreneurial Engineering Enterprises”,” C. Kitts, presentation at the 2011 KEEN Fall Conference, October 7, 2010, Milwaukee, Wisconsin.