

Creating, Educating and Assessing a New Class of Entrepreneurial Minded Engineers

David Pistrui^{*}, Ron Bonnstetter, Bill J. Bonnstetter, and Cynthia C. Fry

***Abstract** – In the last sixty years, engineering education has emphasized the theory deemed necessary to be a valuable and successful engineer. This approach to engineering degree plans has precluded, in many instances, the opportunity for creativity and hands-on innovation in the classroom. One of the stated goals of the Summit Series on the Grand Challenges of the National Academy of Engineering is to “enhance student interest in engineering, science, and technology entrepreneurship.” Of particular interest to engineering programs trying to integrate the entrepreneurial mindset – a combination of technical skills, business savvy, team building and management, and high-integrity leadership – is how to assess the methods by which they measure success in these programs.*

Recent research is proving the value of specific soft-skill competencies. More and more organizations want to hire people that bring those skills to the job. Also, research has suggested that these skills are not curriculum based. Therefore, engineering schools need to incorporate activities and experiences that lead to development of these skills in co- and extra-curricular programs and components.

The Kern Entrepreneurship Education Network (KEEN), a network of eighteen private engineering schools across the U.S., in partnership with Target Training International (TTI), a worldwide leader in personal and professional assessments, is undertaking the KEEN–TTI Performance DNA Assessment Project. Three well-known and vetted assessments are being used to identify current students’ skills, behaviors and motivators to integrate the entrepreneurial mindset into undergraduate engineering education. KEEN has the goal of instilling an entrepreneurial mindset in one hundred percent of all undergraduate students in KEEN schools. KEEN does not have the goal to try and create one single type of engineer, but rather to help all engineers understand, value and apply entrepreneurial thinking.

This paper will lay out the rationale and motives behind the project and provide an overview of the components, as well as some early results. The paper closes with a call to action around a series of questions and the need for long-term focus, analysis and application.

1. Introduction

*Managing Director, Acumen Dynamics, LLC
Assessment Fellow, Kern Family Foundation

In many engineering programs in the United States and around the world, it is no longer sufficient to adequately train engineers with excellent left-brain skills: analysis, logical thinking, and quantitative thought. According to Dean Julio M. Ottino of the Robert R. McCormick School of Engineering and Applied Science at Northwestern University, solving problems is not enough. He states, “There is no prize for solving correctly what may turn out to be the incorrect problem. It is important to acquire the skills to solve the correct problem behind the perceived problem, and this entails more than left-brain thinking alone” (Ottino, 2011). In fact, these right-brain skills, which include competitive differentiation, business adaptability, innovation and the development of a growth culture, and strategic thinking are the “key competencies required to differentiate business in the next two to five years” (Benade, & Heunis, 2005).

As engineering programs strive to meet the challenge of “Educating the Engineer of 2020”, we must acknowledge that the next several decades will offer more opportunities for engineers, and as educators, we must make a shift in our thinking. Instead of permitting engineering education to lag technology and society, “Should the engineering profession anticipate needed advances and prepare for a future where it will provide more benefit to humankind?” (National Academy of Engineering, 2004).

So the question becomes, how do we create, educate and assess the efforts to build a new breed of undergraduate engineers?

2. What is an Entrepreneurially Minded Engineer?

Entrepreneurially minded engineers (EMEs) are the drivers of U.S. innovation and competitiveness and are unique and distinctive (Kriewall, & Mekemson, 2010). EMEs have not necessarily started new businesses although they may have; they do, most often, work in established small- and medium-sized firms, and many work in Fortune 1000 firms (Kriewall, & Mekemson, 2010). It is important to note that there is not a single type of EME, but rather different types who combine their passion for science with professional skills and an opportunity orientation. In other words, “EMEs are not just working on what someone is asking for, but really are defining what the problem is that their firm should be solving” (Tabat, 2010).

To address the need to revive American competitiveness and protect our way of life, KEEN aspires to create a pipeline of a new class of engineers. KEEN was created with the goal to expose all undergraduate engineering students in participating schools to new combinations of curricular, co-curricular and extra-curricular activities and experiences that will foster entrepreneurially thinking in all engineers.

3. KEEN - Developing a New Class of Entrepreneurially Minded Engineers

“The mission of KEEN is not to teach students how to start their own businesses, but to prepare them to think entrepreneurially, particularly more broadly and deeply about how their ideas fit into the growth of the organizations with which they are involved” (Kriewall & Mekemson, 2010, p. 8.) Within this wisdom, KEEN is guided by the central objective to change engineering education in order to empower, encourage, and enable engineers to be active contributors in a free enterprise system, their companies and the communities in which they live and work.

This new breed of engineer must be considered within a global context in terms of whom they will be helping and with whom they are competing. The KEEN EME model is grounded in developing

a new class of engineer through educational reform and new co-curricular and extra-curricular programs and experiences that infuse and blend the following four core components associated with an engineering entrepreneurial mindset (Refer Figure 1).

- *Technical Fundamentals*: EMEs possess both an understanding of the scientific theory and the ability to apply this theory in creative and innovative ways through proof-of-concept designs, design verification, characterization, qualification, validation and standardization for long-term sustainability.
- *Customer Awareness*: EMEs first think in terms of product benefits for the internal and external customers before they think in terms of design features. Thus, customer awareness is the focus of EMEs. They actively engage the market and know how to ask probing questions and, more importantly, how to actively listen. They also serve their internal corporate customers in the same way, viz., to benefit them in their individual roles.
- *Business Acumen*: EMEs have the necessary business acumen to support the organization in which they work. This includes understanding the basics of financial management along with organizational management, including cross-functional team effectiveness, interpersonal communication skills and conflict resolution. Entrepreneurially minded engineers need to know how to be effective cross-functional team players and how to tell their stories in financial terms.
- *Societal Values*: EMEs value and help promulgate the free enterprise system. They promote high standards of engineering and business ethics. EMEs also possess personal character attributes typical of entrepreneurs: intuition, integrity, tenacity, courage and honesty (Kriewall & Mekemson, 2010, p. 8-11).

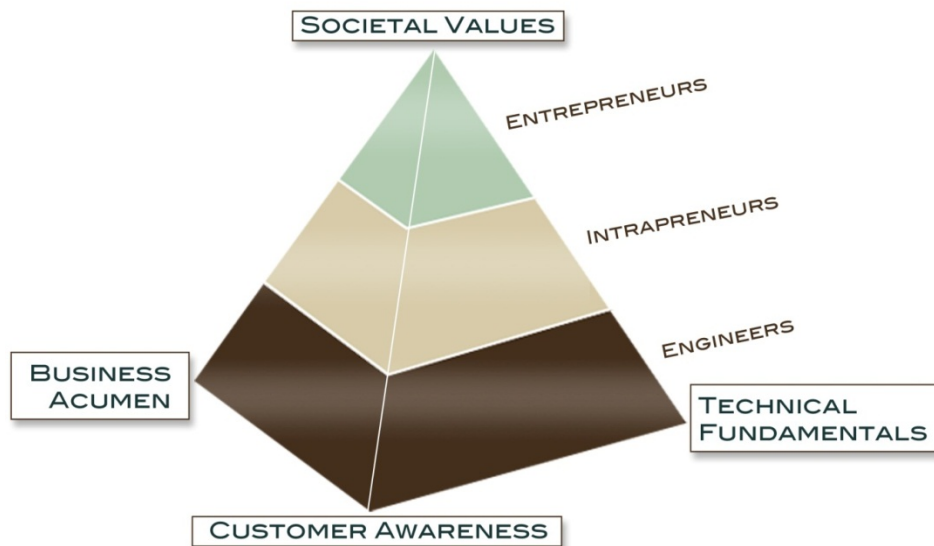


Figure 1. The KEEN Pyramid (Kriewall & Mekemson, 2010)

4. Assessing the Impact of KEEN Programs on Engineering Education Reform

As the KEEN network develops new programs and undertakes engineering education reform, both challenges and opportunities arise. One of the most important questions is how does the Kern Family Foundation (KFF) and KEEN assess and measure the impact of investments made in engineering education reform?

This question is most challenging because the vast majority of the skills, values and behaviors associated with an entrepreneurial mindset may be a new domain to engineering educators since they are rooted in the social sciences. Terms like “acumen”, “awareness” and “values” involve human behavior within environmental and cultural contexts unlike a controlled laboratory or “bench setting”.

Exercising and acquiring great interpersonal and managerial skills are irrefutably important to individual and organizational success (www.spendmatters.com, 2011). Moreover, EMEs combine their passion for science with an aptitude and capacity to develop and apply so-called “soft skills” associated with personal and professional competencies and capabilities. These skills are primarily learned through human interaction and must be practiced outside of a classroom setting.

To address this question, an assessment subcommittee comprised of KEEN faculty, KFF staff and an outside firm, TTI Performance Systems, Ltd., (TTI), a world leader in personal and professional assessment, was assembled to work on developing an assessment framework and methodologies.

In December 2009, the assessment subcommittee identified seven KEEN learning outcomes that students should be able to demonstrate based on their participation in KEEN programs (Pistrui, 2011). The assessment subcommittee recommended that students encountering a KEEN program should be able to:

1. Effectively collaborate in a team setting
2. Apply critical & creative thinking to ambiguous problems
3. Construct & effectively communicate a customer "appropriate value proposition"
4. Persist through and learn from failure
5. Effectively manage projects through appropriate commercialization or final delivery process
6. Demonstrate voluntary social responsibility
7. Relate personal liberties and free enterprise to entrepreneurship

With a benchmark of seven learning outcomes established, KEEN worked with TTI to develop specific methods and frameworks to measure: 1. student demonstration of the seven KEEN learning outcomes; 2. retention of students in undergraduate engineering programs; and 3. assessment of grantee outcomes.

5. KEEN – TTI Assessment Project and Performance DNA

Through the collaborative efforts of KEEN faculty, KFF staff, TTI and Acumen Dynamics executives, a comprehensive assessment framework is being developed and implemented across the network of colleges. Using TTI’s three-part Performance DNA methodology as a model, this team worked to connect the seven KEEN learning outcomes to the personal and professional competencies measured in the instrument (Refer Figure 2). Developing these so-called soft skills are deemed essential to being an effective EME.

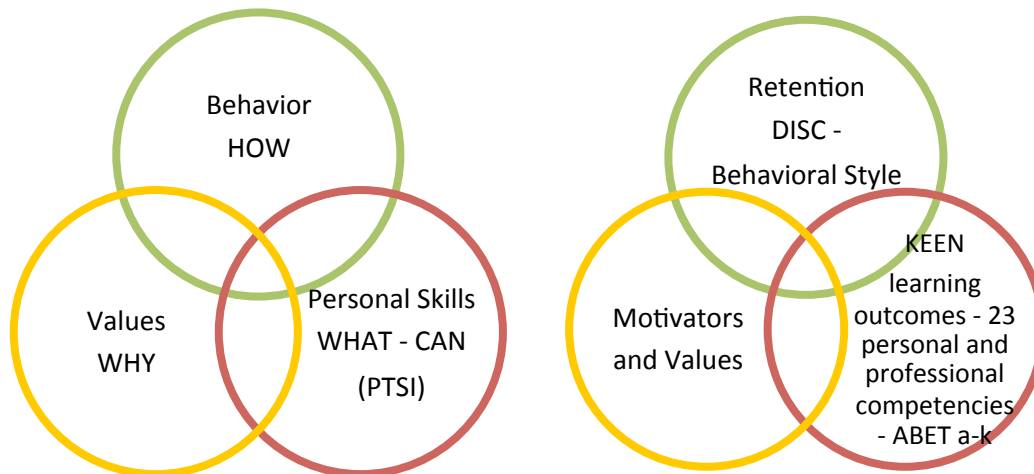


Figure 2. KEEN-TTI Assessment Methodology

Next, the team determined that the behavioral style of participating students could possibly have an impact on their ability to adapt to the rigor of the curriculum. Helping students and faculty to understand their behavioral styles could potentially aid them in adapting more effective study habits and could improve retention. Furthermore, understanding behavioral style within team settings could help students become more effective team members.

The third part of the Performance DNA methodology focusing on values and motives could help students to understand what drives them and to identify and understand the sources and causes of conflict. With these insights, they could better manage their actions in team settings and build communication techniques.

The TTI Performance DNA methodology was designed to increase the understanding of an individual's talents. The TTI Performance DNA report provided insight into three distinct areas:

- *Competencies:* This area includes 23 key job-related competencies and ranks them from top to bottom to define major strengths. The skills at the top highlight well-developed capabilities and reveal where they are naturally most effective in focusing their time.
- *Behaviors:* This section of the report is designed to help attain a greater knowledge of oneself, as well as others. The ability to interact effectively with people may be the difference between success and failure in their work and personal life. Effective interaction starts with an accurate perception of oneself.
- *Motivations:* This section of the report provides information on why one acts, which with application and coaching, can tremendously impact their value of life. Once they know the motivations that drive their actions, they will immediately be able to understand the causes of conflict.

Understanding strengths and weaknesses in each of the three areas could lead to personal and professional development and a higher level of satisfaction.

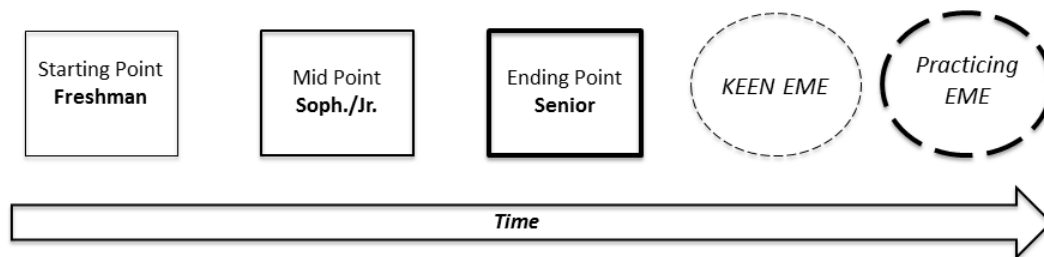
6. KEEN – TTI Performance DNA Assessment Methods

The primary measurement model used to assess student and program outcomes was the seven KEEN learning outcomes and TTI twenty-three DNA personal and professional competencies measurement model depicted below. The seven KEEN learning outcomes were mapped with the twenty-three TTI competencies based on TTI's actual benchmarking of engineering jobs in industry along with the input of KEEN faculty and KFF staff. The twenty-three TTI personal and professional competencies are:

1. Self-management (time and priorities): Demonstrating self-control and an ability to manage time and priorities.
2. Customer Service: Anticipating meeting and/or exceeding customer needs, wants, and expectations.
3. Written Communication: Writing clearly, succinctly and understandably.
4. Goal Orientation: Energetically focusing efforts on meeting a goal, mission or objective
5. Flexibility: Agility in adapting to change.
6. Persuasion: Convincing others to change the way they think.
7. Creativity/Innovation: Adapting traditional, or devising new approaches to, concepts, methods, models, designs, processes, technologies and/or systems.
8. Planning/Organizing: Utilizing logical, systematic and orderly procedures to meet objectives.
9. Interpersonal Skills: Effectively communicating, building rapport and relating well to all kinds of people.
10. Futuristic Thinking: Imagining, envisioning, projecting and/or predicting what has not yet been realized.
11. Presenting: Communicating effectively to groups.
12. Continuous Learning: Taking initiative in learning and implementing new concepts, technologies and/or methods.
13. Teamwork: Working effectively and productively with others.
14. Diplomacy: Effectively handling difficult or sensitive issues by utilizing tact, diplomacy and an understanding of organizational culture, climate and/or politics.
15. Analytical Problem Solving: Anticipating, analyzing, diagnosing and resolving problems.
16. Personal Effectiveness: Demonstrating initiative, self-confidence, resiliency and a willingness to take responsibility for personal actions.
17. Empathy: Identifying with and caring about others.
18. Negotiation: Facilitating agreements between two or more parties.
19. Decision Making: Utilizing effective processes to make decisions.
20. Leadership: Achieving extraordinary business results through people.
21. Management: Achieving extraordinary results through effective management of resources, systems and processes.
22. Conflict Management: Addressing and resolving conflict constructively.
23. Employee Development/Coaching: Facilitating and supporting the professional growth of others.

Through participation in KEEN program activities including curricular, co-curricular and extracurricular experiences, we will measure the capacity of students and programs to develop and master various levels of the 23 personal and professional competencies over time. Research has indicated that most jobs require mastery of approximately seven of the 23 (Refer Fig 3, Bonnstetter, 2009). As the model depicts, we are interested in measuring students' development of these skills at a minimum of three points in their education: 1. Freshmen (benchmark); 2. Sophomore/Junior (midpoint); and 3. Senior (completion of degree).

Seven KEEN Learning Outcomes and the TTI 23 DNA Personal and Professional Competencies (Soft Skills) Measurement Model



1. Measuring change in mastery over time
 2. Measuring change in rank order over time
 3. Benchmarking individual school with KEEN averages over time
 4. Benchmarking students/schools/KEEN with practicing EMEs* over time
 5. Comparative analysis with other assessment tools and techniques
 6. Measuring KEEN program initiatives ability to instill the Seven KEEN Learning Outcomes
- *EME = Entrepreneurial Minded Engineer | KEEN/TTI will build benchmark data base

Figure 3. KEEN-TTI Performance DNA – Methods, models and techniques for assessment, reform and development

It is important to remember that we are at the early stages of this project. This proposed model is a starting point from which to develop a longer term research and educational reform process that seeks to create a new type of engineering education paradigm. As we collect more data and begin to analyze and apply the findings, we are certain that new learning will occur and more complex analysis undertaken. It is important that we keep the learning outcomes central to the model and explore relationships and seek to identify any causality that can be related to programs, activities and learning experiences across the KEEN schools. With a vastly growing and rich database, we have a special opportunity to probe, explore and access outcomes related to undergraduate engineering education.

7. KEEN – TTI Performance DNA Project Launch Recap

As of May 2011, sixteen of the eighteen KEEN schools were participating in the project. Two thousand six hundred and eleven students participated in the launch across the KEEN network. KEEN faculty participated in a series of workshops, webinars and conferences during the launch. A dedicated Web site <www.ttikeen.com> was created that includes two Web clips, a resources section, a link to set up tools and sections for students and practitioners to take the survey.

Faculty was provided with a series of reports, tools and debriefing sessions with TTI and Acumen Dynamics executives. A twelve-school database was created and is now being used for mining and analysis. Each participating school was provided a list of at-risk students and suggested study techniques and tools.

KEEN faculty are already formulating research agendas, including papers for conferences and journal submissions (Pistrui & Fry, 2011, Fry & Jordan, 2011, Reid & Ferguson, 2011, Davis, Hoff & Riffe, 2011, Brouwer, Sykes, & VanderLeest, 2011). It is anticipated that the results of this research will have a transformational effect on KEEN and undergraduate engineering education

for many years, and most importantly, further strengthen the KEEN network's ability to develop a new class of EMEs.

Table 1. KEEN – TTI Performance DNA School Data 2010-11*

<i>School</i>	<i>Fall 2010</i>	<i>Spring 2011</i>	<i>Total</i>
Baylor University	245	117	362
Calvin College	110	10	120
Gonzaga University	-0-	48	48
Illinois Institute of Technology	168	60	228
Kettering University	143	-0-	143
Lawrence Technical University	358	-0-	358
Mercer University	321	-0-	321
Milwaukee School of Engineering	107	-0-	107
Norwich University	-0-	98	98
Ohio Northern University	72	-0-	72
Saint Louis University	48	-0-	48
Santa Clara University	207	115	322
University of Dayton	87	124	211
University of Detroit Mercy	105	22	127
University of Evansville	-0-	23	23
Villanova University	23	-0-	23
Total	1,994	617	2,611

*As of July, 21, 2011

To facilitate the process of integrating the eighteen KEEN schools, a series of support materials that provided a common framework for administration, analysis and feedback were developed and posted to the Web portal. These include the following (available at www.ttikeen.com):

- *KEEN – TTI Assessment Primer* – General overview of projects goals, objectives and time lines and reporting framework
- *KEEN – TTI Assessment Protocol Template* – Provides step-by-step directions on how to set up, administer, lead debrief sessions and use reports and data
- *IRB Template* – Provides a model for faculty to apply for and obtain approval to conduct human subject research
- *TTI Link Set Up Form* – Provides template for the information required to set up links for students to take the survey
- *Study Habit Recommendations* – Developed at the University of Nebraska-Lincoln for the undergraduate engineering program
- *Introductory Video Clip* – Provides a general overview and introduction for students to view prior to taking the survey
- *Debrief Video Clip* – Provides a general overview of the report and how students can use this information to enhance personal development

8. Results of the Fall 2010 Benchmark Twelve School Data Set

During early 2011, a data set from twelve participating KEEN schools was created at the request of faculty. This data set represents a collection of first-semester freshmen across these twelve schools with a total of 1,412 observations.

Table 2. Fall 2010 Twelve School Data Set

Baylor University – 225	Calvin College – 110
Illinois Institute of Technology – 169	Kettering University - 143
Lawrence Technical University - 215	Mercer – 65
Milwaukee School of Engineering - 107	Ohio Northern University - 72
Santa Clara – 208	University of Dayton – 40
University of Detroit – 35	Villanova – 23

N = 1,412 – March 2011

In an effort to establish a benchmark, a sorted average ranking of the students' 23 personal and professional skills was created. The intention was to get a general sense of the skill levels, and even more importantly, some sense of strengths, weaknesses and areas of opportunity in terms of skill development.

Items 11-23 are noteworthy with a series of themes emerging: 1. the need to develop leadership skills; 2. the need for work on communication skills; 3. a low opportunity orientation and forward-thinking capabilities; 4. a lack of understanding of creativity and innovative approaches; and 5. a lack of decision making skills.

These basic insights are a valuable starting point as the KEEN Network develops individual and collective programs, methods and offerings both in and outside of the classroom. Most of these 23 skills are not curriculum based, and therefore faculty and administrators will need to review current models and formulate new learning paradigms in order to produce a new class of EMEs.

<ol style="list-style-type: none"> 1. Goal Orientation 2. Continuous Learning 3. Teamwork 4. Personal Effectiveness 5. Interpersonal Skills 6. Management 7. Planning Organizing 8. Customer Service 9. Employee Development/Coaching 10. Analytical Problem Solving 11. Self-Management 12. Diplomacy 13. Leadership 14. Conflict Management 15. Persuasion 16. Presenting 17. Creativity/Innovation 18. Written Communication 19. Empathy 20. Flexibility 21. Negotiation 22. Decision Making 23. Futuristic Thinking 	<ul style="list-style-type: none"> • Ranking between schools were almost identical • Insights into skills/competencies that need development • Bottom third are vital and need integration into education • Co-curricular, extra-curricular are important components • Research ongoing to benchmark engineers in practice
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N=1.412 – March 2011

Figure 4. KEEN Twelve Schools Sorted Average Rank of 23 Personal and Professional Skills

9. Results of the 2010 Freshmen KEEN Benchmark Point

Data from the twelve participating KEEN schools was compared with an actual engineering job benchmark: the present freshmen student status and the national mean for working adults. The actual engineering job benchmark refers to typical results for a person doing the job at the present time (referred to as “job” in the table below). The present freshmen numbers refer to the average score of our first year freshmen.

Research indicates that these skills are age related, and for freshmen not to have as many of these skills as adults indicates a valid study design. Replicating this technique and tracking changes in student skill development over time will allow KEEN to measure and assess the impact of various schools’ programs impact on developing and shaping students around the seven KEEN learning outcomes.

The following table shows an example of the results of the KEEN 2010 freshmen class with respect to the twenty-three personal and professional competencies and skills. This is the benchmark study, and KEEN will continue longitudinally throughout the students’ academic careers.

Table 2. Job Competencies Hierarchy Comparisons

Question	Working National Mean	Actual Engineering Job	Mean for KEEN freshmen
Self Management	4.4	9.5	4.49
Customer Service	6.3	9.2	4.77
Written Communication	5.4	8.9	3.55
Goal Orientation	6.8	8.8	6.23
Flexibility	4.5	8.3	3.21
Persuasion	5.5	8.3	4.01
Creativity/Innovation	4.8	8.2	3.68
Planning/Organization	4.8	8.0	4.98
Interpersonal Skills	6.8	7.8	5.15
Futuristic Thinking	2.8	7.7	2.01
Presenting	6.1	7.6	3.75
Continuous Learning	6.1	7.5	5.94
Teamwork	6.3	7.2	5.54
Diplomacy	5.9	7.2	4.20
Analytical Problem Solving	4.7	6.5	4.57
Personal Effectiveness	5.5	6.5	5.26
Empathy	3.6	5.9	3.23
Negotiation	3.8	5.7	2.78
Decision Making	4.0	4.8	2.52
Leadership	6.1	4.7	4.08
Management	5.7	4.1	5.10
Conflict Management	5.2	3.3	4.02
Employee, Development/Coaching	6.8	2.9	4.63

Scale 0-10 n = 1,412

Overall, these results compare reasonably well but are below the national TTI average. This is to be expected as the results are for first-semester freshmen. What is more important to consider, however, is that we have established a benchmark that suggests the ability to address the development of personal and professional skills vital to being an effective engineer, as well as measuring the seven KEEN learning outcomes.

10. Student Retention and the TTI DISC Universal Language Assessment Model

The TTI DISC Universal Language method that examines behavioral styles can be used to help students and faculty understand how they respond to certain type of learning environments. With heightened awareness, students can adapt their study habits and interactions with others in team settings. Faculty can also use this information to identify at-risk students based upon previous research using the TTI DISC methodology.

Retention of undergraduate engineering students is an issue impacting most schools. For example, during a November 2010 meeting, Mercer University Associate Dean Michael Leonard indicated that on average 15% of freshmen engineering students drop out. Through examining the KEEN network of eighteen active schools with an average of 150 incoming freshmen per school and a 15% drop out rate, then approximately 400 potential new engineers are lost annually. At the University of Nebraska-Lincoln, 76% of the freshmen engineering students who dropped out had behaviors and motivators common in people who have entrepreneurial tendencies. This research has been completed for the last six years, and the grade point averages of these students tended to be lower than those fitting into the typical college engineering culture.

There was a misfit with the “job” of being a college student. Entrepreneurs and entrepreneurially minded engineering students tend to conflict with the culture found in typical public engineering schools. Our current research with the private engineering schools suggests they are doing a better job of maintaining entrepreneurs and entrepreneurially minded students.

We may conclude from these examples that we are not only losing a significant number of undergraduate engineering students, but we also may be losing some students who, with some modification in study habits and mentoring, could go on to complete an engineering degree. Given the shortage of engineers, this knowledge might be useful to KEEN schools to better assist all students through programs, activities and counseling.

To address these challenges, KEEN will employ the TTI’s behavior, motivator and soft skills assessments to identify at-risk freshmen and encourage faculty and administrators to work together to retain these individuals.

Based upon the retention challenges and the objectives of the KEEN network, the second dimension of the KEEN – TTI Assessment Project addresses is student retention. This phase of assessment will have all incoming freshman take the TTI Performance DNA using the results to: 1. identify at-risk students as soon as possible, 2. engage these students with counseling and guidance, and 3. provide study habit behavioral guidelines to assist students. The assessment and measurement metrics will be used in tracking retention rates of students engaged in KEEN schools at three points: 1. Freshmen, 2. Sophomore/Junior, and 3. Senior. KEEN student retention assessment metrics include the following:

1. Measuring change in freshman retention over time
2. Measuring change in retention class year over time
3. Benchmarking individual school with KEEN retention averages over time

DISC is a four-quadrant behavioral model based on the work of Marston (1928) to examine the behavior of individuals in their environment or within a specific situation. It therefore focuses on the styles and preferences of such behavior. DISC is an acronym for

Dominance/challenge: How one addresses problems and challenges.

Influence/contacts: How one handles situations involving people and contacts.

Steadiness/consistency: How one demonstrates pace and consistency.

Compliance/constraints: How one responds to rules and procedures set by others.

This system presents an assortment of dimensions of observable behavior that has become known as the universal language of behavior (Marston, 1928). Research finds that characteristics of behavior can be grouped into these four major "personality styles", and they tend to exhibit specific characteristics common to that particular style (Marston, 1928). All individuals possess all four, but what differs from one to another is the extent of each.

Understanding a person's natural way of operating in each of these areas gives a reliable indication of how they will tend to behave on the job—in this case, the job of being an engineering student. When students answer the questions in online assessment processes, they have their own unique profile plotted on a graph, along with a full report of their unique profile.

DISC can also be a valuable framework for faculty and administrators to better understand, counsel and guide students. By understanding a person's behavioral style, faculty advisors can help students adapt their learning styles, better understand how to interact with other behavioral patterns, and therefore, navigate the challenging world of engineering education leading to improvement in retention and performance.

11. Building on the Foundation and a Call to Action

Much has been accomplished during the first year of the KEEN – TTI Performance DNA Assessment Project, yet this is only the beginning of a long-term commitment of instilling an entrepreneurial mindset in one hundred percent of all undergraduate students at KEEN universities. Through the partnership of the Kern Family Foundation, KEEN, TTI and Acumen Dynamics, we are working together to address a vital issue confronting the U.S.: the need to retain and create work -ready entrepreneurial minded engineers for the twenty-first century.

With a solid base established, now is the time to extend and expand efforts across KEEN. Now is the time for KEEN and TTI to focus on the following action items:

- *Launching Phase II of the KEEN – TTI Performance DNA Assessment Project* during the 2011-2012 academic year. This includes the goal of reaching all freshmen the first two to three weeks of the school year across KEEN.
- *Advocating and advancing the continued development of the KEEN – TTI partnership* through continuing to strengthen faculty and administration support, understanding and addressing retention, publishing in scholarly journals and presenting at conferences.
- *Compiling, cleansing and analyzing the first set of data* generated by the KEEN – TTI Performance DNA Assessment Project to gain further insights and identify opportunities to leverage and share this knowledge. This includes using this knowledge to improve curricular and non-curricular offerings and to publish and present research results.
- *Leveraging a self-selected collection of KEEN schools* (nine total) that have banded together to form two dense networks. Together, these schools will use the KEEN – TTI

Performance DNA Assessment Project to address retention and instill the seven KEEN learning outcomes in all students where appropriate.

- *Accelerating the creation of a new work-ready class of engineers* by instilling an entrepreneurial mindset in one hundred percent of all students in KEEN schools. Sharing this model with others can lead the reform and transformation of undergraduate engineering education in the U.S.

12. Developing a New Class of Entrepreneurially Minded Engineers

Today there is a great need to develop a new class of entrepreneurially minded engineers in America. In 2008, one in four workers in America with a degree in science, technology, engineering or math were 50 or older (Economist, 2011). For America to remain competitive and innovative we need a new type of engineer, one who has technical competence, an entrepreneurial mindset and a complementary set of personal and professional competencies. The research presented in this work is an effort to address these dire needs, and to urge others to heed this important call. Undergraduate engineering education reform, including understanding the need to complement the engineer's passion for science, with the ability to work and lead diverse teams, be more effective communicators, tell their stories in financial terms and be opportunity seekers are vital.

The KEEN – TTI Performance DNA Assessment Project serves as an example of a pro-active collaborative effort of a network of private engineering programs, and industry, that embraces a common vision and set of learning outcomes aimed at creating a new set of technical professionals to lead American in the twenty-first century and beyond.

Special thanks to the participating KEEN schools for their commitment and long term pledge to transforming undergraduate engineering education and American competitiveness in a changing global economy.

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