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## **AC 2012-3655: PROPOSED KEEN INITIATIVE FRAMEWORK FOR ENTREPRENEURIAL MINDEDNESS IN ENGINEERING EDUCATION**

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# **Proposed KEEN Initiative Framework for Entrepreneurial Mindedness in Engineering Education**

## **Abstract**

The development of a comprehensive logistic structure is essential to ensure the success of implementing the vision of the Kern Entrepreneurship Education Network (KEEN) initiative to forcefully push engineering education to further the characteristic of entrepreneurial mindedness in engineering graduates.

The logistic structure must begin with the KEEN Educational Objectives (KEOs) since they define the direction and end results desired. The KEOs in turn are furthered by assuring students at the time of graduation have achieved the KEEN Student Outcomes (KSOs). The curriculum and extracurricular activities have the function of developing the professional and technical traits defined by the outcomes, which in turn allow the objectives to be pursued and achieved. Alignment of these items is critical to ensure not just the objectives are met but also to ensure the curriculum and outcomes actually influence and affect each other in the intended manner.

It is highly advantageous that the proposed structure aligns and is compatible with the ABET Engineering Criteria, which is well-established and well-understood by engineering programs. This would simplify interpretation of language and could serve to minimize any additional assessment work.

## **Introduction**

The Kern Entrepreneurship Education Network (KEEN) educational initiative in engineering has the goal to increase the number of entrepreneurially minded engineering graduates in the US.<sup>[1][2]</sup> To achieve that requires the establishment of curricula content and extracurricular activities within existing engineering programs. Such a process is naturally related to key aspects of the ABET accreditation process, as defined by the Engineering Criteria.<sup>[3]</sup> Up to now the KEEN initiative has not had such formality of specific language and structure. That is a significant shortcoming since the intent is to assess activities and changes associated with the curriculum and other components of the educational process. Since ABET is such a well-established and dominant factor in specifying student outcomes and a continuous improvement process, it is highly advantageous to have a KEEN process that mirrors and is compatible with ABET. This paper investigates the aspects critical to the KEEN educational process, how they directly relate to the ABET accreditation requirements, and provides a comprehensive overview and understanding regarding how the KEEN process needs to be ordered in order to improve its chances of actually having the impact on engineering education it is aiming for.

## **Understanding ABET**

Since ABET accreditation based on the Engineering Criteria (earlier called the Engineering 2000 Criteria) is an essential aspect of virtually every engineering program it would be reasonable to utilize ABET, especially in matters of language, to avoid asking engineering programs to have

two sets of definitions and to ensure the assessment process imposes a minimum workload on participating institutions and associated faculty. A key component that programs must address in the Engineering Criteria relates to Criterion 2 and 3, Program Educational Objectives and Program Student Outcomes. Understanding the role of these items in how they define a program is central to understanding the purpose of a program in how it is attempting to relate its curriculum to the future of its graduates.

ABET educational objectives and student outcomes can best be understood from a top-down perspective.<sup>[4]</sup> Which of these comes first is not at all a chicken-and-egg argument. Educational objectives come first. Then student outcomes can be properly understood and take on a useful meaning. The educational objectives are defined in terms of the early career paths the graduates of the engineering program are being prepared for and generally expected to follow. In other words, once the students leave the academic nest, the question is what did we prepared them to do? Where might they go and what do we hope/expect them to do? Hence, the sequential process of program development is:

- **ABET Program Educational Objectives (PEOs)** are broad statements that describe the expected career and professional accomplishments of the first several years following graduation that the program prepared the graduates for.
- **Student Outcomes (SOs)** constitute the body of knowledge of what students are expected to know and attributes they will have developed by the time of graduation such that they will have the capability to successfully fulfill the program objectives.
- **Program Curriculum** is the last piece of the process and is developed to ensure that the desired body of knowledge and understanding is imparted to the graduates. The organization of the curriculum is usually prescribed in the form of course requirements but does allow for considerable innovative means of conveying knowledge and the development of attributes.

This process of program development must involve and be driven by the constituents of the program (faculty, prospective employers, students, and others, as defined by the program).

### Equivalent KEEN Structure

The distinct desire of the KEEN initiative is to change the engineering educational process such that the resulting graduates have both the competencies currently expected of graduates and an entrepreneurial mindset that not just fosters innovation, but also results in contributing to the manufacturing of goods and services that are competitive in a global marketplace. Since the manner of achieving that goal must by necessity deal with curriculum matters, both formal courses and informal settings such as faculty-student interactions, the initiative constitutes an educational process that significantly parallels the already well defined ABET accreditation process that assesses students before and after graduation.

First, we need to establish some basics of vocabulary for the KEEN initiative.<sup>[5]</sup> The structural components are proposed to consist of:

- **KEEN Educational Objectives (KEOs)** – Again, the KEOs describe the early career trajectories of the graduates and are established with input from the stakeholders/constituents of the engineering program. Natural stakeholders are the Kern

Family Foundation, employers, faculty, administration, students, and, in the future, alumni.

- **KEEN Student Outcomes** (KSOs) – The KSOs describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and attributes that students acquire as they progress through the program. The outcomes have the specific purpose of assuring the graduates have capabilities that further the achievement of the KEOs.
- **Program Curriculum** – The curriculum and other interaction with students, such as advising and monitoring student academic progress, are designed to further the student characteristics and qualities that result in a mindset for entrepreneurial thinking and performance.

The overall structure may be compared to a fruit tree. The curriculum, courses, and other program aspects are the trunk that supports the outcomes and objectives. The branches form the structure of the program outcomes. Finally, the objectives are the flowering and fruition yielded by the educational process.

It should also be noted that while outcomes can and are often broadly written, from a practical standpoint they must be implemented in a manner consistent with the needs of employers of the graduates. However, in this case they must also do more than meet the normal expectations per the ABET outcome. The KEEN outcomes also must be met.

## Overlapping Missions

The ABET Student Outcomes are defined as <sup>[1]</sup>:

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The KEEN Student Outcomes are defined as:

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 (to understand what is needed to succeed)
5. Effectively manage projects and apply the commercialization process

6. Demonstrate voluntary social responsibility
7. Relate personal liberties and free enterprise to entrepreneurship

Comparing the two sets of outcomes it is evident that there is considerable overlap.

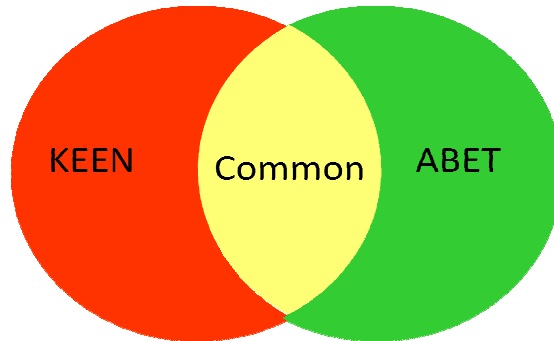


Figure 1. Overlapping Student Outcomes

What is also evident is that KEEN has a specific mission component that ABET does not have. This has a significant impact on curriculum and extracurricular activities since those items not done by ABET need to be added to the overall list of items that a program must strive to accomplish. There is a similar impact on the assessment process.

There is a basic decision to be made. And, that is how to relate KEEN and ABET since they will coexist in all engineering programs that choose the path of adopting the KEEN Student Outcomes. We propose two simple conclusions:

**Let ABET do what ABET does**

**KEEN does that which ABET does not do – form entrepreneurially minded graduates**

What this means and its impact on assessment are:

- Accept and use ABET assessment/evaluation of (a-k) presented by an academic program
- KEEN specifically assesses KSOs (and KEOs) **not covered by (a-k)**
- Provides direction and defines what you need to assess/evaluate

These points must be understood with the KEEN Student Outcomes being our primary focus. The practical answer of how to proceed is for an engineering program to map its ABET Student Outcomes into the KEEN Student Outcomes. Such a mapping process is program dependent and Figure 2 would represent the result for some possible programs, but not for others. It really depends on how the curriculum is structure, the details of the where and how faculty further the KEOs.

Mapping of ABET Student Outcomes to KEEN Student Outcomes - <b>Proposal</b>			Map Well	Maps Possibly Sufficiently	Maps Insufficiently
<i>KEEN Program Outcomes - A student should be able to:</i>		<i>ABET Student Outcomes</i>			
1	Effectively collaborate in a team setting	d	x		
2	Apply critical & creative thinking to ambiguous problems	c, h		x	
3	Construct & effectively communicate a customer-appropriate value proposition	g		x	
4	Persist through, and learn from failure (to understand what is needed to succeed)				x
5	Effectively manage projects and apply the commercialization process				x
6	Demonstrate voluntary social responsibility	c, f		x	
7	Relate personal liberties and free enterprise to entrepreneurship	i		x	

Figure 2. Possible Mapping Result – ABET into KEEN Student Outcomes<sup>[5]</sup>

### Assessment Process Consideration

#### *Curriculum Design*

Some words should be expressed regarding the design and implementation of a curriculum and the extracurricular activities that would result in graduates with an entrepreneurial mindset, a mindset that would be demonstrated with career entrepreneurial behavior. Programs are rightfully centered on ensuring the body of knowledge normally associated with the discipline will be instilled into students. That is rightfully their primary business. Central to an engineering curriculum are the technical, science and math courses. Our experience from ABET and other professional activities suggests programs design their curriculum around courses that are “right” for the discipline and less so around the “right attributes” of its graduates. Hence, including the intent of the KEEN initiative we think one could state:

*“Right” courses = Right body of knowledge (probably true)*  
*“Right” courses ≠(?) KEEN Student Outcomes (no reason to believe to be true)*

The need to address the professional components described in both the ABET and KEEN Student Outcomes was always there, but the extensive global competitive climate has changed the equation so that now it is essential to do so. Professional skills are generally addressed in specific courses; example – ethics. There are occasional efforts, such as a focus on writing,<sup>[6][7][8]</sup> efforts that are difficult to sustain. Our experience suggests that programs chairs and deans quite likely will state their programs do a reasonable job of addressing outcomes associated with

professional skills. If that is true, why do employers keep emphasizing the need for improvement?

The KEEN Student Outcomes have an even greater dependence on the “softer, professional” competencies than is required by the ABET Student Outcomes, and, hence, pose a significantly higher hurdle. Greater insights and innovation in how to design the curriculum are needed to address this issue. A central example would be demonstrated by the statements:

*Entrepreneurial engineering mindset – solving problems customers need to have solved*  
*Often encountered engineering mindset – solving problems you want to solve*

How will choice of courses and content and activities differ when considering the furthering of an entrepreneurial mindset? If that choice is not affected by the desired ultimate result, the result will be what it always has been.

### *Assessment*

Central to the evaluation of a success curriculum and associated extracurricular activities is an assessment process that measures the degree to which the curriculum results in students being steeped in the desired outcomes at the time of graduation and alumni who successfully engage and execute the desired objectives.<sup>[9][10][11][12]</sup> Having specifically emphasized the top-down nature of the design of the program and its impact on assessment, there is a “bottom-up” aspect to the assessment process because of the timeline associated with the various aspects of the educational and career fulfillment process. Specifically:

- Curriculum components can typically be assessed in a time period ranging from three months (academic quarter system) to one year. Longitudinal studies would take longer.
- Student outcomes require student to reach the point of graduation. Hence, they typically require 3-4 years if the impact of changes in the lower academic years is being assessed.
- Objectives require both graduates and some reasonable time for the pursuit of a career path. The total time would typically range from 6-7 years before any meaningful assessment could be made.

Anecdotal data points should not be interpreted as forming a confirmed pattern. Virtually any program will have individual students and graduates who will achieve whatever results one is seeking.

Our goal is the education of entrepreneurially-minded engineers. That education is guided by the seven KEEN outcomes. As these outcomes are rooted in social sciences and involve human behavior within environmental and cultural contexts, a sophisticated assessment tool is needed.

We are beginning the process of doing a longitudinal assessment of student attitudes and skills. The TTI Performance DNA methodology<sup>[13]</sup> was chosen for its ability to provide deep insight into a person’s:

- Competencies (23 job related aptitudes such as teamwork, diplomacy, empathy)
- Behaviors (how one interacts with others and with one’s environment)
- Motivations (these are the why’s behind one’s actions)

We have begun administering this assessment to the freshmen, juniors, and seniors in our programs. We currently have data from two years of freshmen, and by the end of spring 2012 we will also have data from two years of juniors and seniors. While this data will provide us a snapshot of where we are at the present time, it is hoped that we will see changes in student's perspectives and behavior over the course of their four years at the university. The wider KEEN network is also seeking to get practicing engineers to take this assessment so that we have a standard to compare to.

The KEEN-TTI Performance DNA assessment data will be used, along with other standard assessment tools (those used by the individual institutions) to answer the following three questions:

- How effective are the intrapreneurship curricular elements and intercollegiate projects at creating entrepreneurially-minded engineers?
- How effective are the intrapreneurship curricular elements and intercollegiate projects from a pedagogical perspective?
- How successful are the students when viewed through an intrapreneurship lens?

How will the assessment process differ when considering the furthering of an entrepreneurial mindset? If the assessment methodologies do not specifically account for the ultimate goal in specific ways, the assessment results will not offer the desired proof of change.

### *Alignment*

A key factor that drives the success of instilling the desired outcomes and achieving the desired objectives is the alignment of the objectives, outcomes, and curriculum with respect to each other. They must be consistent with each other, each reinforcing the other. If that does not happen, then it is perfectly possible to have a curriculum that does an excellent job of instilling knowledge, skills, and attributes that are different from the specified outcomes. Or, it is possible to have assessment data that demonstrate strong attainment of the stated outcomes, but the outcomes do not foster any higher degree of entrepreneurial mindedness than a traditional engineering curriculum. This is why the top-down model is critical in the implementation of any program. And, that understanding is critical in setting up the assessment process.

### **Proposed KEEN Educational Objective**

We propose the following KEEN Educational Objective be adopted by KEEN:

- Graduates who will pursue careers that result in entrepreneurial-minded endeavors

The objective meets the essential requirements that it focus on activities post-graduation and it can be readily assessed. Survey of graduates will be able to capture information such as project contributions, patents, leadership positions, etc. The objective is strongly supported by the KEEN Student Outcomes.



## Conclusions

It is important that the initial top-down alignment is done right, so it only needs to be done once. There seldom is the time or patience to wait the number of years to allow an educational process to settle down and provide long-term data. That means since the KEEN logistic structure is an addition to the ABET requirements an engineering program is to address it must:

- Define the desired results
- Do the right thing
- Do it the right way
- Minimize the work asked of faculty
- Assesses the results

The curriculum and assessment process must be designed right so it will be implemented only once and not suffer from successive iteration. Any changes should be data driven.

Specific next steps:

- Adopt one (or more KEOs) – want FEW, well defined KEO(s); must be assessable. One such objective is proposed in a prior section.
- Identify the KEEN Outcomes that ABET does not cover (very well or not at all) – mapping process
- Identify key DNA attributes that entrepreneurially minded graduates must possess and map to KSOs
- Develop curriculum/extracurricular activities to enhance the essential attributes
- Ensure alignment of KSOs “up and down”
- THEN develop an assessment plan

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