An Emerging Template for Professionally Oriented Faculty Reward Systems that Supports Professional Scholarship, Teaching, and Creative Engagement in Engineering Practice for the Development and Innovation of Technology

**D. A. Keating,[1] T. G. Stanford,[1] J. W. Bardo,[2] D. D. Dunlap,[2] D. R. Depew,[3] G. R. Bertoline,[3]
M. J. Dyrenfurth,[3] A. L. McHenry,[4] P. Y. Lee,[5] E. M. DeLoatch,[6]
S. J. Tricamo,[7] H. J. Palmer[8]**

**University of South Carolina[1] / Western Carolina University[2] / Purdue University[3]
Arizona State University East[4] / California Polytechnic State University[5]
Morgan State University[6] / New Jersey Institute of Technology[7]
Rochester Institute of Technology**

Abstract

This is the third of three papers prepared for a special panel session of the National Collaborative Task Force on Engineering Graduate Education Reform that addresses reform of faculty reward systems to advance professional engineering education for creative engineering practice and technology leadership. This paper presents a roadmap for planned reform in defining a model template for professionally oriented faculty reward systems that supports professional scholarship, teaching, and engagement in advanced engineering practice for the creation, development & innovation of technology. Four action items are presented based upon the urgency for reform in U.S. engineering education and the unifying themes, common to other professions, in advancing professional education for practice.

1. Introduction

Since the end of World War II, the United States has invested heavily, and quite successfully, in fostering research-driven graduate education for the development of the U.S. scientific workforce, which performs discovery-oriented basic scientific research at the universities.

Subsequently, in the last half of the last century, faculty reward systems that assess productive faculty scholarship at the nation's colleges of engineering and technology have focused largely on the linear research-driven model of technology development and quest for federal funding of research, which originated in 1945 U.S. science policy.[1]

Cultures for discovery-oriented scientific research and research-oriented graduate education have proven to be quite successful at most research universities. The existing faculty reward system, developed since 1945 and nurtured by federal research grants, meets the needs and requirements of most research-oriented faculty who, for the most part, are very good at performing their functions as scientific researchers and are rewarded accordingly. These cultures have a long tradition in academia.

However, during this same time period, a balanced effort has not been given to creating a complementary infrastructure at the universities that is required for the advanced professional education of the U.S. engineering workforce in industry, which is performing the "lion's share" of engineering for the deliberate creation, development and innovation of new/improved/breakthrough technology for the nation's economic development and national security. This neglect has been a major contributing factor to the long-term loss of U.S. competitiveness and to the long-term underdevelopment of the U.S. engineering workforce for technological innovation and its effective leadership.

1.1 History of Early Origins of Research-Oriented Scientific Education for "Discovery" in Europe

As with any engineering approach for major improvement, the National Collaborative Task Force for Engineering Graduate Education Reform is addressing the reform of faculty reward systems from an overall systems approach: First, by investigating the need for change, and second, by investigating the history of what led to the existing situation in the first place.

From this background analysis, the Task Force has learned that the origins and philosophies of a scientific education to "discover" and of an engineering education to "create" have often been confused as being one in the same. *They are not.*

Also, the Task Force has learned that the needs-driven engineering process itself — to deliberately conceive, develop and innovate new meaningful technology for actual use — has too often been confused with the process of science, or considered a sequential follow-on process to scientific research. *It is not.* Accordingly, many universities need to reassess their missions, goals, and objectives for engineering and science; and respond with broader vision to the educational needs of their constituencies if the nation is to compete more effectively in the innovation-driven economy.

Higher-education is deeply ingrained with traditional thought and embedded with traditional culture from the past. However, the culture for purposeful engineering innovation and the culture for scientific research are quite different. Thus, any group which seeks educational reform must understand the history of the past in order to bring about effective change for the future. As such, change agents also must understand the differences in the multifaceted cultures which must coexist and which must be nurtured within great universities.

Research cultures have had a long history in higher-education. As Ferguson notes: "By Newton's time, the European intellectual community had been deeply influenced by Francis Bacon's grand scheme to enhance the power and greatness of man through science." [2] Bacon laid much of the early framework for emphasis on teacher-centered instruction and on research-oriented scholarship using the scientific method for "discovery" of new scientific knowledge. As a result, Bacon's philosophy in the 17th century has had a far reaching influence on higher education as it exists in many universities today.

As Boyd noted in his landmark work of The History of Western Education:

> "In the new age on which men were entering Bacon took the place of Aristotle as the master of those who sought to know and to teach. The *advancement of knowledge* became the catchword of many of those who aspired to a reformation of life and thought, and through them came to be an integral part of the modern ideal of education … A considerable number of literary and scientific men were eager to see the foundation of a college for the advancement of science after the manner of the "Solomon's House" which Bacon had outlined in the *New Atlantis*, and the funds necessary for the institution of this college, seemed likely to be provided by Parliament." [3]

But, as Boyd reflects: "the rapid approach of civil war put an end to these fine plans and it was not till the Restoration that they received a very different fulfillment in the creation of the Royal Society (1662)." And, it was not until much later in the 19th century, as Boyd notes, that the founding of the Humboldt-University in Berlin (1810) gave rise to the early origins of university discovery-oriented scientific research and education. Boyd noted that: "Berlin university was not intended to be a mere addition to the number of existing universities but was created to embody a new conception of university work. The main emphasis was laid on scientific research rather than on teaching and examining; and with this view the professors appointed were chosen for their capacity to make original contributions to the furtherance of learning."

1.2 History of Early Origins of Research-Oriented Scientific Education for "Discovery" in the U.S.

The Humboldt-University model strongly influenced the growth of research-oriented education across the Atlantic after several Americans studied at this new university. By the late 19th century, the advancement of knowledge through *research* had taken firm root in American higher education and a new type of university was emerging.[4]

Just thirty-four years after the founding of America's experiment in "land-grant" colleges for the practical arts and engineering (1862), Woodrow Wilson, then president of Princeton (1896), described Johns Hopkins as the first university in America where the "discovery of knowledge" was judged superior to "mere teaching."

By the early part of the 20th century, a pattern for scientific research for discovery and teaching was developing in the United States. John Dewey, America's leading philosopher and educator at the time, proclaimed in 1916 that America was in a new progressive era driven by the scientific method for discovery and scientific inquiry, wherein Dewey proclaimed as a result that ─ "Technology is the practical correlate of science."[5]

By 1928, academic scientific research and the characteristics of a scientific education for "discovery" were beginning to gather momentum wherein Alfred North Whitehead, described five major aims of education as follows: [6]

(1) "A scientific education is primarily a training in the art of observing natural phenomena, and in the knowledge and deduction of laws concerning the sequence of such phenomena."

(2) "The peculiar merit of a scientific education should be, that it bases thought upon first-hand observation."

(3) "The universities are schools of education, and schools of research. But the primary reason for their existence is not to be found either in the mere knowledge conveyed to the students or in the mere opportunities for research afforded to the members of the faculty."

(4) "The university imparts information, but it imparts it imaginatively. At least, this is the function which it should perform for society. A university which fails in this respect has no reason for existence."

(5) "Do you want your teachers to be imaginative? Then encourage them to research."

1.3 History of Research-Oriented Scientific Education for "Discovery" at Mid-Century in the U.S.

By mid-century, the focus of America's universities to advance the progress of new scientific knowledge through research was beginning to take shape. As a result, Bacon's linear-research driven philosophy of technology ─ implying that "scientific discovery" was the engine for innovation and the primary driver of engineering practice for technology development ─ was beginning to be born.

By 1945, as Ferguson has pointed out, it was Vannevar Bush who patterned Bacon's belief and formed the vision for a compact between federal government and the research universities citing that basic scientific research for "discovery" was the capital, forerunner, and primary driver for the nation's thrust for technology development and innovation to sustain the nation's technological posture for defense, economic development, and general welfare. Thus, in 1945 the linear-research driven perspective of basic scientific research ─ as the primary driver of engineering practice for technology development and innovation ─ was fully born.

As a result of 1945 U.S. science policy and the compact that was created between government and the research universities, the linear-research driven perspective of technology was built into the nation's schools of science and engineering in order to develop the nation's top scientists who would thus be the creators of the nation's future technology. A few schools tried to resist this notion.

By 1955, ten years after initiation of federal funding for research, the Grinter Report was written.[7] Although the Grinter Committee recognized in its preliminary report that one type of education for the nation's scientists and for the nation's engineer's doesn't fit all, this perspective was eliminated in the final report as bifurcation was not allowed. As Ferguson notes, many schools of engineering were already receiving federal grants for academic scientific research and found it quite difficult to resist this new type of funding for the support and development of their faculty.

The linear research-driven perspective of technology innovation became interwoven into the philosophy of engineering education itself and into the faculty reward system. As a result, the linear research-driven perspective of how technology is created, developed and innovated has had enormous influence on the education of the nation's future engineers and on how engineering faculty are rewarded at most schools of engineering which have subsequently become research-oriented.

1.4 A Call for Change in Engineering Education in the Last Half of the 20th Century in the U.S.

During the 1960's, 70's, and 80's, a few leaders in the engineering schools began to realize that creative engineering practice for the creation, development and innovation of technology was quite different from that of scientific research which primary purpose is to gain a better understanding of phenomena to add to the body of scientific knowledge.

These leaders began to recognize that engineering education was drifting away from its primary mission and was beginning to founder with its almost singular emphasis on research. The consequences, the leaders feared, would have long-term effects on the development of the nation's creative engineering workforce and the nation's innovative capacity for future technology development and innovation for economic growth, national security, and betterment of the quality of life. Their forecasts were correct — and the results are showing up over the long-term with America's decline of technological competitiveness and with many engineering graduates in industry not understanding the *engineering method* and believing that engineering development is a linear sequential process that follows basic scientific research.

In 1969, Eric Walker, chairman of the ASEE-Goals Report, wrote a seminal paper, *Teaching Research Isn't Teaching Engineering*.[8] But few listened. By this time, the faculty reward structure in most engineering schools equated *"scholarship"* with scientific research and the successful quest for federal research funding as the forerunner of technology. This perspective was already built solidly into the educational system, and Walker's call for reform fill on deaf ears.

During the 1990's, higher education began to realize that great universities serve multifaceted missions and functions in addition to research wherein professional education, undergraduate education, and other forms of education were gaining unrest on the campuses. There was a growing tension that all was not right in higher-education with its almost singular focus on research.

In an attempt to open the universities to new ways of thinking about education, teaching, and research, Boyer produced a landmark report in 1990 in an attempt to get at the core issue for improvement of higher-education in order to better serve the needs of various constituencies.[9] Although Boyer's comments were focused on undergraduate education, they extend to professional education as well.

As Boyer noted:

- "At the very heat of the current debate ─ the single concern around which all others pivot ─ is the issue of faculty time. What's really being called into question is the reward system and the key issue is this: what activities of the professoriate are most highly prized? After all, it's futile to talk about improving the quality of teaching if, in the end, faculty are not given recognition for the time they spend with students."
- "Following the Second World War, the faculty reward system narrowed at the very time the mission of American higher education was expanding, and we consider how many of the nation's colleges and universities ware caught in the crossfire of these competing goals."
- "In the current climate, students all too often are the losers … Faculty are losing out, too. Research and publication have become the primary means by which most professors achieve academic status, and yet many academics are, in fact, drawn to the profession precisely because of their love for teaching or for service ─ even for making the world a better place. Yet these professional obligations do not get the recognition they deserve, and what we have, on many campuses, is a climate that restricts creativity rather than sustains it."
- "Colleges and universities are also weakened by the current confusion over goals … It is time to ask how the faculty reward system can enhance these efforts … The rich diversity and potential of American higher education cannot be fully realized if campus missions are too narrowly defined or if the faculty reward system is inappropriately restricted. It seems clear that while research is crucial, we need a renewed commitment to service, too."
- "Thus, the most important obligation now confronting the nation's colleges and universities is to break out of the tired old teaching versus research debate and define, in more creative ways, what it means to be a scholar. It's time to recognize the full range of faculty talent and the great diversity of functions higher education must perform."
- "For American higher education to remain vital we urgently need a more creative view of the work of the professoriate … Finally, we need a climate in which colleges and universities are less imitative, taking pride in their uniqueness. It's time to end the suffocating practice in which colleges and universities measure themselves far too frequently by external status rather than by values determined by their own distinctive mission. But let's also candidly acknowledge that the degree to which this push for better education is achieved will be determined, in large measure, by the way scholarship is defined and, ultimately, rewarded."

2. Reinventing America's Universities for the 21st Century

Although Boyer tried to make the case for reform ─ it did not make the case completely ─ Bacon's influence has had far reaching effects on the philosophy of education itself and on scholarship for over three centuries. The Boyer Report still placed discovery oriented scholarship as the forerunner and did not completely recognize other types of scholarship that require other types of creative intellectual thought processes (such as creative engineering practice responsive to real-world needs). The National Collaborative Task Force on Engineering Graduate Education Reform believes that Boyer's ideas represent a first attempt at faculty reward system reform. More work needs to be done. Boyer's four points were as follows:

(1) *The scholarship of discovery*

(2) *The scholarship of integration*

(3) *The scholarship of teaching*

(4) *The scholarship of application*

2.1 Some Semantics of Technology Development & Innovation

Whereas Whitehead and Dewey were correct in the early part of the 20th century about their perspectives of a scientific education for *"discovery"*, their perspectives of a technological education for engineering and the relationships between science and technology fall far short of our understanding of a technological education and the *"engineering method"* which is used in the 21st century for the deliberate creation, development and innovation of new/improved/breakthrough technology and what we want our creative engineers to become.

Dewey's assertion that ─"Technology is the practical correlate of Science" ─ or that engineering is "applied science" is no longer perceived correct. Technology and the process of engineering practice that creates new technology have been redefined in the 21st century (National Academy of Engineering).[10, 11]

The essence of engineering is creative problem-solving and creative development to deliberately bring forth new technology and effective solutions to meet the hopes, wants, and needs of society for the general betterment of human welfare. In this sense, William Wulf, president of the National Academy of Engineering has rightfully pointed out that: "Engineering is design under constraint." [12]

As such, creative engineering practice is *neither* viewed any longer as a secondary, follow-on function to basic/or directed scientific research *nor* is engineering development perceived any longer as that which translates research findings into technology.[13,14,15,16] As a consequence, the advanced professional education of engineers can no longer be considered identical to the education of research scientists, although learning the fundamentals of science is vital and necessary to an engineer's education.

2.2 Creating a New Vision

Engineering has changed substantially from Bacon's time and from the linear research-driven perspective of technology development and innovation portrayed by 1945 U.S. science policy. Thus, for America to regain its technological competitiveness in the innovation-driven economy, universities must reinvent themselves in many ways ─ especially in professional engineering education.

A new model for needs-driven, systematic engineering innovation has emerged in the 21st century. Academic scientific research and technology development are no longer viewed as linear, sequential activities. Although directed scientific research is often used in the development of new technology, *it is not the primary driver!*

A new paradigm for engineering has emerged. Today, engineering practice for creative technology development and innovation and directed scientific research for "discovery" are viewed as concurrent activities with unique roles and functions wherein the educational requirements of these two activities are quite different. Full recognition of this new paradigm will have profound effect upon the rate of advancement of U.S. technology and the advancement of professional education for engineering practice which directly influence the need for new faculty reward systems for those faculty who educate in the professional arena of creative engineering practice for innovation.

2.3 The Creative University

As Duderstadt has put forth, it's time to reinvent the university and to reform universities for the development of creativity and such professions such as engineering. [17] He notes: "Perhaps the university of the twenty-first century will also shift its intellectual focus and priority from the preservation or transmission of knowledge to the process of creation itself."

The National Collaborative Task Force believes that the term scholarship is farther reaching than presently defined in academia. It encompasses all creative forms wherein discovery is but one form. Accordingly, the National Collaborative Task Force believes that there are other forms of scholarship in addition to scientific research. The Task Force believes that the uniqueness of professional scholarship of engineering for the creation, development and innovation of new technology must be more clearly defined in order to make sustainable reform during this century.

As Schein noted: "The state of ferment in the professions and in the educational establishment makes this a good time to rethink education for the professions … It is increasingly obvious that the professional of the future must have a different set of skills, a different self-image, a different set of attitudes from the professional of today." [18]

The importance that this reform plays in advancing high-quality professional engineering education for innovation and the importance that the engineering profession plays in ensuring the nation's technological progress for competitiveness are far reaching. As Schein pointed out: "The professions have always been the agent by which society dealt with its major problems … It is the professions, therefore, which must continue to change and evolve to deal with new problems and new complexities, using the continually growing knowledge and technological base that is available."

Today, it is time to extend university education beyond the imparting of knowledge to include the development of innate human potential for creativity, innovation, and leadership in engineering. It is the practicing profession of engineering whose central aim is to create, develop and innovate new technology to make this technology base available to society.

2.4 At the Turning Point for Breakthrough in Professional Engineering Education

Although the U.S. system of graduate education has served our nation well for the graduate development of university scientific researchers at the nation's schools of engineering and technology, the professional complement of engineering education must be reinforced substantially to meet new challenges of the 21st century relevant to the systematic practice of engineering itself for the leadership of creative technology development and innovation in industry and government service. As the U.S. competes in the 21st century, it is competing in a technology-based economy, which is innovation-driven and global.

However, America's competitiveness has declined during the last three decades. There are several factors for this decline. One important factor is the issue of improving quality and process in U.S. higher-education itself in the nation's schools of engineering and technology. In hindsight, a balanced financial investment has not been made since 1945 in fostering a complementary path of excellence for professional practice-oriented graduate education for the U.S. engineering workforce during this same time period. Lack of a balanced approach in engineering education has contributed to a long-term underdevelopment of the U.S. engineering workforce which has been subsequently reflected in the loss of U.S. competitiveness.

Without denigrating the vital role that university scientific research plays in the nation's continuing contribution to the advancement of science, it is now evident that creative engineering practice in industry plays the primary role for the continuing advancement of U.S. technology and our competitiveness as a nation. Technology is primarily created, developed and innovated by the U.S. engineering workforce in industry. However, because of an unbalanced educational emphasis and almost singular focus on scientific research and discovery at most schools of engineering and technology, it is now evident that the U.S. engineering workforce has been underdeveloped during the last three decades.

Today, many universities have recognized the need to change to better meet the needs of their constituencies. While many historical traditions of universities are excellent, were good for their time and must be protected, times have changed. Some traditions are limiting and outmoded. Many U.S. universities *neither* have kept pace with the educational needs of their constituencies in practice-oriented engineering education at the undergraduate level *nor* at the graduate level, *nor* have they kept pace with the modern concepts of how people learn, grow and develop in creative professional practice.

Many universities are adhering to only a narrow part of Whitehead's 1929 vision of a university, wherein he noted that: "The university imparts information." In imparting information, faculty were perceived to become also the generators of new knowledge gained through the method of science for inquiry; to become teachers of future academic researchers who would later discover new knowledge themselves through inquiry; and to become transmitters of knowledge for the education of practitioners, such as in engineering who would later apply the knowledge in practice in industry.

Whitehead's and Dewey's perspectives of a scientific education laid much of the foundation for the linear research-driven model of technology development and U.S. science policy in 1945. This perspective laid the foundation for much of engineering education in the 60's, 70's, 80's, and 90's at the undergraduate and postgraduate levels. As Ferguson noted, the 1945 model built largely upon the linear research-driven model of science-driven technology both in the education of engineers and in their practice. But the process of innovative engineering has changed substantially from that perceived by the 1945 linear research-driven model of engineering practice.

However, the perception that technology development arises primarily from basic academic scientific research as the driver is still pervasive. The myth lives on today in many colleges of engineering and technology across the country. It fosters an almost singular emphasis that great universities must become research universities, favors a research-oriented faculty, and places professionally-oriented faculty on a much lower intellectual level as simply the "appliers of science" which is generated by the research-oriented faculty.

A few universities are now beginning to redefine scholarship as it applies to scholar practitioners, notably Western Kentucky University and University of St Thomas. There are others, but more focused work needs to be done in this area. A critical mass of innovative universities must be nurtured to share both "best practice" and new thinking to accelerate reform synergistically across the country. The National Collaborative Task Force intends to catalyze this critical mass with key leaders from the universities in partnership with the practicing profession in industry.

3. Action Plan for Reform: Setting a New Direction for the 21st Century

The National Collaborative Task Force believes that reshaping tenure and promotion policies for professionally-oriented engineering and technology faculty is urgently needed in order to make advancement in professional graduate education sustainable. However, the Task Force clearly recognizes that the reshaping of university policy for faculty reward system reform will not happen overnight.

3.1 Reexamining the Situation

The Task Force has taken a hard look at the situation and is reflecting on the most probable approach to positively impacting the system to achieve the goals for reform for professionally-oriented faculty in engineering and technology. The effort to reform the university faculty reward system must be undertaken with great understanding of the factors that pervade the environment and heavily mediate any attempt at successful change. Some of the existing factors are:

(1) The faculty reward system is one of the major levers of administrative control in universities

(2) The axis of control is the T&P process where the existing operational values are:
   a) Publication in refereed journals
   b) Funded projects and grants that pay the federal overhead rate
   c) Outside evaluation of performance by respected academic peers

(3) 1 and 2 above form the core of an ingrained system that we are not likely to change in a short period of time

(4) Currently university administrators are using these processes to select and guide the faculty toward the fulfillment of specific university goals and outcomes.

3.2 The Process for Planned Reform

Although change in universities has been evolutionary, the Carnegie Commission on Higher Education pointed out in 1972 that reform can be accelerated more effectively through planned change.[19] Reform can be accelerated with educational leadership and resurgence for reinventing the mission and purposes of universities for the 21st century. However, reform *can not* occur without real change. As Schein noted:

- "Professional education can be changed by a deliberate yet controlled process. We do not have to rely on the slow process of evolution, nor would it be appropriate or desirable to have a more drastic revolutionary kind of educational reform. We seek a process that lies somewhere between these two extremes and that has worked well in the transformation of a variety of other kinds of organizations … The *essence* of a planned change process is the *unlearning* of present ways of doing things. It is in this unlearning process that most of the difficulties of planned change arise."

- "It should be noted that if a change program is to be successful, it must pay particular attention to stages 1 *(Unfreezing)* and 3 *(Refreezing)*. It is not enough just to develop and publish new ideas and to expect that others will take them up, or to give vivid examples and hope that others will, through identifying themselves with our situation, see the relevance of the example and then adopt it … Many innovative ideas in education are never attended to because there is no motivation to change in the first place, and many that are attempted fail to survive because they are not integrated into the total system of the school or the personality of the teacher trying out the innovation.."

- "This point is absolutely crucial: *no matter how much pressure is put on a person or social system to change through disconfirmation and the induction of guilt-anxiety, no change will occur unless the members of the system feel it is safe to give up the old responses and learn something new.* Without a feeling of psychological safety, the members of the system will increase in defensiveness in direct proportion to the amount of pressure brought to bear."

- "We can see many examples of this mechanism operating in professional school faculties: new program ideas will not be tried because faculty members are afraid that students will learn less or be hurt by a new approach, or because they are unsure unless someone else has already tried it and can reassure them that it will work, or because they are reluctant to expose their fear of not being able to use the new idea effectively."

- "Fears will often be rationalized in terms of economic arguments or in term or attributing problems to some other groups. In all these cases one must consider the possibility that what the person is really saying is that *he* is feeling threatened and /or does not see how to get there from here hence he tends to resist on an emotional level and develop rationalizations for the resistance … Unless the norm itself is changed, only those innovations that faculty members have invented or selected for themselves will be genuinely integrated into the curriculum."

3.3 Roadmap for Planned Change

But change is underway. As such, the Kellogg Commission recommends that universities must become more engaged institutions with their constituencies: "The clear evidence is that, with the resources and superbly qualified professors and staff on our campuses, we can organize our institutions to serve both local and national needs in a more coherent and effective way. We can and must do better." [20] This involves going beyond extension to become more productively involved with our communities. Part of this community is the practicing engineering profession within industry which involves also the further professional graduate education of practitioners.

But, planned change for practice-oriented engineering education must be defined with full understanding of the existing research-oriented, academic organizational culture, and identify: a) what facts will be accepted; b) what facts will be denied, and; c) what will be the inevitable resistances that will occur if the existing research-oriented academic culture perceives this change to be a threat to their way of life or not complementary to it. As Barwise and Perry emphasize: "Different organisms can rip the same reality apart in different ways, ways that are appropriate to their own needs, their own perceptual abilities and their own capacities for action … For while reality is there, independent of the organism's individuative activity, the structure it displays to an organism reflects properties of the organism itself. [21]

As such, this reform must be complementary to the existing organizational culture for scientific research.

This reform requires the definition of new unit criteria for engineering practice which must not be forced into the traditional academic culture and faculty reward system for scientific research if it is to sustain. Accordingly, university visions must be broadened to allow this transformation to occur. This vision suggests complementary unit criteria for faculty performance, because the missions and objectives of research-oriented education are quite different from practice-oriented engineering education for creative technology development, innovation, and leadership studies. To meet the challenge, the National Collaborative has formed a Sub-Committee on Faculty Reward System Reform which is developing an action plan and roadmap for planned change from a systems approach. This is a work in progress. The action plan includes the following:

- ***ACTION 1: To Define Scholarship and Creative Intellectual Performance in Engineering Practice***
  - Task 1: To review the definition of scholarship as it is implemented in practice in other service professions such as law and clinical medicine
  - Task 2: To review faculty reform underway in other practice-oriented engineering programs e.g. Western Kentucky University and University of St. Thomas etc.
  - Task 3: To differentiate the functions, characteristics, and scholarship of advanced engineering practice for technology development & innovation from basic/ or directed scientific research
  - Task 4: To contrast the "engineering method" for creating, developing & innovating new/improved/breakthrough technology responsive to real-world needs with the "scientific method" in gaining a better understanding of phenomena and creating new knowledge. Following Boyer's model in recognizing the Scholarship of Discovery as the operant verb for new "science", the action team feels that this reform should clearly reflect the Scholarship of Engineering as the operant verb for the creation and conceptual design of new "technology"
  - Task 5: To contrast the progressive proficiency levels and progressive skill-sets of professional performance in advanced engineering practice from that of scientific research for discovery

- Task 6: To define the differentiating characteristic of scholarship of advanced engineering practice for creative technology development and innovation from those functions of scholarship for basic or directed scientific research.
- Task 7: To review the promotion process of demonstrated proficiency as it applies to advanced professionals in industry/government service
- Task 8: To define unit criteria for professional scholarship and creative intellectual performance relevant to the advanced practice of engineering for creative technology development and innovation for tenure and promotion at all professorial ranks

➢ ***ACTION 2: To Define Characteristics of Teaching - Mentoring Professionals for their Growth***

- Task 1: To define the mentoring relationship between professional-oriented core faculty and participants in industry for technology development & innovation as contrasted with the mentoring role of research-oriented faculty and graduate students for scientific discovery
- Task 2: To define the mentoring attributes that promote growth of working professionals in industry for the development and innovation of new/improved/breakthrough technology
- Task 3: To define the role of faculty as mentors in the experiential learning process
- Task 4: To use new concepts of how creative engineers learn, grow, and develop as creative professionals and leaders of technology development in industry
- Task 5: To share best practice for educating working professionals
- Task 6: To define the role of faculty mentors in project-based (problem-centered) innovation-based learning as the foundation of the *engineering method* for technology innovation

➢ ***ACTION 3: To Define Engagement at the Advanced Professional Level in Engineering***

- Task 1: To define engagement to include the range of professional activities from consultancy through participation in creative project development teams
- Task 2: To differentiate engagement in engineering from that of directed scientific research
- Task 3: To define the key roles of core faculty for engagement on technology development & innovation projects with working professional participants in industry
- Task 4: To provide expertise in policy making for advanced professional education
- Task 5: To provide expertise in socio-technology-economic issues

➢ ***ACTION 4: To Create New Financing Schemes that Sustain Advanced Professional Education***

- Task 1: To review the financing of other professional colleges such as law for sustainability
- Task 2: To define new ways for funding advanced professional engineering education though industrial partnerships, gifts, endowments, and tuition that fully support core faculty in matrix university organizations for 12 months
- Task 3: To create new faculty reward systems that encourage the mentoring of working professionals in industry on technology development & innovation projects.
- Task 4 To create new financing schemes for sustainability that permits scholarship, creativity and technological innovation to flourish for collaborative work

4. Drawing the Right Conclusions ─ A Work in Progress for Planned Reform

The panel has restated the urgency for reform of faculty reward systems to advance professional education at U.S. colleges of engineering and technology for the nation's general welfare and technological competitiveness. Analysis of the commonality of characteristics found in faculty reward systems for other professions such as law and clinical medicine has been made. The commonality reflects three unifying themes: professional scholarship, teaching, and engagement. These unifying themes form the basis for planned change in creating a new template for professionally-oriented faculty reward systems that supports teaching, professional scholarship, and engagement in advanced engineering practice for the creation, development and innovation of new/improved technology. The panel has defined four key action items which serve as a roadmap for the National Collaborative sub-committee. This is a work in progress. The National Collaborative Task Force is accelerating its work with a critical mass of key leaders from innovative universities working in partnership with key leaders from industry.

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Biography

DONALD A. KEATING is associate professor of mechanical engineering, University of South Carolina, and program chair ASEE-Graduate Studies Division.

THOMAS G. STANFORD is assistant professor of chemical engineering, University of South Carolina.

JOHN W. BARDO is chancellor of Western Carolina University.

DUANE D. DUNLAP is professor and department head of engineering technology, Western Carolina University, and Secretary/Treasure ASEE-Graduate Studies Division

DENNIS R. DEPEW is professor and dean of the school of technology, Purdue University.

GARY R. BERTOLINE is professor and associate vice president of information technology, Purdue University.

MICHAEL J. DYRENFURTH is assistant dean of graduate studies of the school of technology, Purdue University.

ALBERT L. McHENRY is dean of the college of technology and applied sciences at Arizona State University East, and former Chair of the Engineering Technology Council of the American Society of Engineering Education.

EUGENE M. DELOATCH is dean of the school of engineering, Morgan State University, and a past president of ASEE and member of ASEE Board of Directors.

PETER LEE is dean of the college of engineering, California State Polytechnic University.

STEPHEN J. TRICAMO is professor of industrial and manufacturing engineering, and former dean of engineering and technology, New Jersey Institute of Technology.

HARVEY PALMER is dean of the Kate Gleason college of engineering, Rochester Institute of Technology.