Re-Engineering Higher Education for Responsive Engineering and Technology Leadership

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Abstract

Today, global economic competitiveness and public policy responsiveness are primary driving forces for continuous technological development and innovation in engineering and technology professional practice. A new model of purposeful, systematic technology innovation has evolved and regional industries and government must continuously develop their innovative capacity (intellectual property) to stay competitive and sustain economic growth. Graduate education must reflect this change, understand the new relationships between customer needs, directed scientific research, and engineering/technology leadership. For the U.S. to sustain global competitiveness, traditional graduate studies must undergo educational reform. The three broad mandates for this collaborative effort are:

- To create new models of needs-driven, professionally oriented graduate education through the master and doctoral levels that better support engineering and technology innovation.
- To involve industry and government as key partners in this advancement for both national and regional economic development.
- To provide new mechanisms for sustained collaboration among the participating universities, by using a new internet-based communication that enables collaborative scholarship without regard to geographical location.

The strengths of the alliance are the critical mass effect for educational change that results through multi-university collaboration, and the rapidity for the exchange and sharing of new ideas, experiences, and scholarship through the use of electronically mediated communication, which is required to make this transformation a collective reality.

1. Introduction

The purpose of this paper is to describe a new collaborative alliance among universities across the U.S. and Canada, which has been purposefully formed in 2000 as an outgrowth of ASEE's Graduate Studies Division to address this needed transformation in higher education. The authors of this paper submit that a myriad of complex and increasingly interdependent economic, technical, social, and political forces are driving an expectation for greater accountability and responsiveness from engineering and technology leadership (ETL) professionals. Equally, we expect that a key responsiveness issue for the North American higher-education enterprise involves transforming roles, responsibilities, and relationships related to engagement of the ETL communities it serves. Ultimately, we are calling for a dialogue leading to the re-engineering of ETL graduate professional education and other continuing professional development so it is responsive to the needs of working ETL professionals and closely aligned with actual processes of industrial innovation and technology development.[3] We submit that re-engineering ETL graduate professional education is an appropriate and necessary engagement strategy for

American higher education. We further submit that this contribution must be grounded in building and keeping long-term, mutually-beneficial relationships between higher education and society, particularly as it relate to supporting capacity-building for economic development and addressing important public policy issues (for example, aging infrastructure, climate change, responsible development, et cetera). A prototype graduate educational model under the leadership of Duane Dunlap is aligned with goals for state-of-the-art engagement has been practiced for three years in the School of Technology at Purdue University, with over 60 full-time professionals representing over 35 different corporations.[2]

Together, we frame the context for change by taking stock of key forces impacting the practice of ETL. We propose re-engineering ETL graduate professional education to reflect the realities of the 21st century. We look at the need for models of graduate professional education that are responsive to stakeholders' needs and which complement established models of research-oriented graduate education. For example, stakeholders of the Purdue University model have validated the applied, practical problem-solving model using directed project outcomes. The authors also explore the need for inter-sectoral, inter-institutional, and inter-disciplinary collaboration in the process of evolutionary graduate professional education model development. The theoretical discussion focuses on exploration of the experience-to-date in two research-intensive universities grappling with the issues of nurturing graduate professional education within strong research cultures. All universities having engineering, technology, or engineering technology graduate programs can benefit from this model.

2. Taking Stock of Key Forces and Development Challenges

A recent environmental scan[4] of senior engineering leaders in industry and government incorporated as part of a major educational needs assessment in engineering management[5] highlighted that change was universally reported as a theme that professionals in ETL roles are compelled to address. Key changes, issues and trends reported, include:

- Globalization of economies (for example, building and operating new facilities in diverse locations with diverse cultures).
- Social expectations to demonstrate "social conscience" in safe work practices, environmental protection and being "good" corporate neighbors.
- The expectations of public and the stakeholders to be more involved in decisions they perceive as affecting their lives, including the surrounding environment (for example, interest-based responses to managing development and the growth).
- Technological, regulatory and competitive changes at local, regional, national and international levels driving a continual repositioning and reinvention of businesses.
- Continuous business process reinvention as a way to increase productivity from existing yet diminishing resources.
- Decreasing half-life of usable competitive knowledge (rates vary by industry).
- Client demands to get more work done faster (for example, by concurrent engineering).
- A business environment where the customer defines the solution.
- New forms of relationships and partnerships between the private and public sector in infrastructure management and research and development (for example, Build-Own-Operate-Lease partnerships).

- New forms of relationships and partnerships among engineering service providers whose clients are demanding "best-of-class" collaboration for solutions (for example, strategic alliances with vendors).
- Workforce composition (for example, the emergence of dual career families and the aging workforce) and responding to some of the opportunities that diversity in the workplace presents (for example, along gender, cultural, generational boundaries).

These powerful change forces prompt a reexamination for how ETL professionals develop and how higher education supports that development in response to challenging, contemporary work environments.

Traditionally, promotion to ETL roles has occurred through demonstrating outstanding technical performance in engineering and technology roles.[6] One inherent challenge with promoting engineering and technology professionals into ETL roles based on past success in applied technical practice, is that the knowledge, skills, and attributes necessary for success in a professional technical role do not automatically translate into the range of competencies necessary today for outstanding ETL performance.[5] There is increasing awareness at a policy level that engineering and technology professionals must make deliberate and consistent efforts at career-long learning that is role-related and performance-oriented.[7,8]

However, there is concern at present, that higher education is not consistently delivering career-long learning that is aligned with actual industrial innovative technology development processes.[3] Sharpening the focus between what is required by ETL professionals and what universities are delivering to support the career-long development of ETL professionals continues to be an urgent strategic policy issue that is often unmet in universities' relationships with society generally, and the industrial community in particular.[9]

Ferguson[7] reminds us that rapidly changing knowledge and requirements in engineering and technology requires employed professionals formally educated in an engineering, technology or science-related pre-professional program, to develop new skills and acquire more specific knowledge. Since knowledge specific requirements are a moving target, it is a critical success factor to better equip ETL professionals for each of the succession of engineering and technology roles in a career. For example, the National Society of Professional Engineers[10] has identified nine developmental levels through which professional engineers typically evolve, and has documented a corresponding competency and performance profile for each level. To satisfy career-long learning developmental needs, requires focused and responsive, up-to-date, industry-relevant graduate professional education.

America's higher education response to engineering and technology management over the last half-century has seen explosive growth in the number of engineering and technology management programs, particularly at the graduate-level. Engineering and technology management programs, as known today, began with the University of Washington introducing a M.S. degree program in engineering management in 1947, and UCLA initiating an engineering executive program the same year.[11] Since 1996, Kocaoglu[12] had documented the existence of 212 engineering and technology management programs globally, with a vast majority of these programs being offered by US-based institutions.

More than half of the existing engineering and technology management programs are a by-product of the North American research university culture that emerged during the last half-century. This culture is predominantly based on a science-driven, basic-research model that finds its roots in policy developments arising out of the 1945 Bush report, *Science: The Endless Frontier*. The reality, however, is that most modern industrial innovative technology development does not find its genesis in the research university laboratory. Hence, it is driven by the everyday, nitty-gritty details of living in a complex world of markets, needs, opportunities and responses to complex social, technical and policy problems.[13] Most "real world" innovative technology development occurs through a purposeful, systematic needs-driven process using the creative engineering method.[3,14]

Re-engineering ETL graduate professional education so that it is responsive to and aligned with actual innovative technology development processes is a complementary strategic choice for higher education. Engineering and technology leadership does not negate the importance of traditional science-driven, basic-research oriented graduate education. Rather, it reflects an evolution and maturation of ETL graduate professional education so that it is more closely aligned with the needs of practicing ETL professionals.

In order to reengineer ETL graduate professional education so that it is responsive to the needs of practicing professionals, there are two key engagement challenges facing higher education. First, pathways must be found that enable new graduate programs based on actual industrial innovative technology development practices, and second, the programs and their stakeholders must be allowed to emerge and flourish within strong basic-research cultures. Within the existing sectoral and institutional cultural milieu, faculty members continue to be primarily rewarded for pursuing research, often at the expense of the teaching and service missions of higher education. A concomitant challenge is to create the aforementioned pathways for more responsive graduate professional education programs, while honoring the past role and contribution of the traditional science-driven, basic-research model.

3. Engagement as the Mission-Driven Rationale for Graduate Professional Education

Those being served by graduate professional education (that is, learners, governments, businesses, non-profit organizations, et cetera) determine its responsiveness. Each stakeholder community judges higher education by the quality of their relationships and the quality of the outcomes of those relationships.[15] A concern within industry is that the "ivory tower" is not sufficiently sensitive to the educational implications of the rapid pace and nature of contemporary change.[16] This prompts a very legitimate question raised by educational administrators at institutions offering engineering and technology management programs: What impetus is there to make such programs more responsive to the needs of stakeholders? One obvious response is: The stakeholders not only expect, but also in many cases demand greater responsiveness from higher education in supporting needs-driven, market-responsive, career-long learning.

Much has been recently written about responsive higher education (see, for example, Rhodes[17]). The context for institutional change in higher education has been thoroughly processed at the sectoral-level through initiatives such as the catalytic work of the *Kellogg Commission of the*

Future of State and Land-Grant Universities.[18] The Kellogg Commission was supported by a $1.2 million grant from the W. K. Kellogg Foundation and led by a 25 member blue-ribbon presidential commission. Five overarching themes[19] emerge from the work of the Kellogg Commission and provide a mission-driven rationale for exploring models of graduate professional education which are responsive to ETL career-long learning:

1. *Accountability to society and key publics* – An emerging sense that higher education is not adequately sensitized to, responsive to, or structured to address contemporary social priorities, problems, issues and opportunities (for example, supporting economic development).

2. *Supporting and leading social transformation* – A growing expectation that higher education is seen as taking informed, anticipatory, and strategic, leadership roles in engaging stakeholders and making meaningful contributions to constructively address community problems, social issues and economic development opportunities that arise from globalization, urbanization, demographic, socio-political, technological and other changes that are profoundly altering the human condition.

3. *From "outreach" to "engagement"* – A call for a basic re-conceptualization of the nature of higher education's relationship with the communities it serves, as well as the evolved role and relationship of service relative to higher education's mission. This represents a conceptual and programmatic shift from "the experts in the ivory tower" bestowing expertise and insight, to a needs-driven, problem-oriented, collaborative two-way exchange between higher education and the stakeholder communities it serves.

4. *Aligning institutions for responsive engagement results* – Higher education is organized by departments and not by structures that are readily responsive to social issues or community concerns, issues, or opportunities. Aligning institutions for results involves clear leadership and support of engagement as well as strengthening responsible academic freedom and specialization, while finding incubating and integrating mechanisms and strategies to focus higher education's resources in addressing social and community issues. It also means aligning faculty incentives and higher education organizational structures to be more responsive to the legitimate and valued social and economic development priorities of the communities in which higher education operates.

5. *Revisiting scholarship* – Based on the seminal work of Ernest Boyer,[20, 21] scholarship is envisioned, supported, practiced and rewarded as the process of creating and communicating knowledge through an integrated and seamless process of teaching, research, and service.

The context for mission-related change and re-engineering in graduate professional education emerges out of the relationship between higher education and society, and is grounded in a growing sense that institutional structures and practices are misaligned and often disconnected from the pressing needs of society. This theme is reflected in recent literature from senior US higher education leaders.[17, 22, 23, 24,25,26,27,28] The outcome is articulated as a growing disconnect between the work of higher education and the implied social covenant for contributing to addressing the everyday problems, issues and opportunities of society.

4. A Journey to Responsive Graduate Professional Education in ETL

As we begin the journey to responsive graduate professional education in ETL, two challenges emerge. First, we must address structural and cultural barriers in higher education. The dominant science-driven, basic-research paradigm and present culture in higher education has contributed to a climate where valuable conduits for mutual creative-problem solving, knowledge-creation and communication between the academy and society are often seriously lacking. [27, 28] Second, we must address the situation wherein research, teaching and service currently are not integrated. New concepts of engagement, however, "are premised on the fact that teaching and learning, research, and engagement and outreach are interrelated; and needed to nourish the public-serving university for the next century." [26]

Conceiving ETL graduate professional education as a key engagement strategy for higher education transforms educational responses and relationships with stakeholders to ones where higher education is playing a necessary and valued strategic capacity building function in society. For us to capitalize on the full potential of a transformed approach to ETL graduate professional, re-engineering initiatives must be based on a thorough and accurate assessment of needs, opportunities, prospective responses to internal as well as external forces, and an understanding of and respect for stakeholder interests. For positioning higher education to be responsive, re-engineering efforts are challenged to focus on actual and anticipated professional practice requirements, related enabling competence and capabilities, and corresponding learning and change requirements for ETL professionals. Indeed, a transformed approach to ETL graduate professional requires a transformed approach to thinking about our roles and responsibilities in higher education, especially in the implied social covenant related to engagement, as expressed by the integrated pursuit of research, teaching and service for the greater social good.

What we have been discussing regarding the future of ETL graduate professional is, if not revolutionary, certainly transformational in nature. Creating a future involves a baseline on a very different set institutional practices and assumptions than have been pursued over the last half century in American higher education. It involves change, and change management including curriculum re-engineering that acknowledges program development as a value-laden process involving the management of real and symbolic power.[29] Although it might surprise and frustrate the technical-rational sensibilities that permeate natural science and engineering academic cultures, informed educational planners acknowledge that in addition to being a technical exercise, re-engineering in program development inevitably reflects value expressions and social constructions of the planners and the stakeholder communities engaged.

So, how might we get to a place that celebrates the contributions of the traditional science-driven, basic-research culture in higher education while making way for complementary needs-driven, creative engineering-based models of ETL graduate professional? One way is through the creation of an ETL community of practice.[30] At the most basic level, a community of practice is a small group of people working together over a period of time. Communities of practice are not a teams, not a task forces, and often not even an authorized or identified groups. People in communities of practice can collaborate on a shared task (such as creative problem-solving or model development) or work together on products or processes (in teams comprised of, for example, engineers, educators and information management specialists). These communities are

peers in the execution of "real work" (such as innovative technology development). What holds communities of practice together is a shared sense of purpose and accomplishment for the common good. There are often communities of practice within a single institution, and most people belong to more than one of them. A community of practice is different from a community of interest and defines itself along three dimensions[30]:

1. What it is about – it is a *joint enterprise* as understood and continually renegotiated by its members.

2. How it functions – *mutual engagement* and pursuit of mutual goals that, in independent pursuit, would not lead to either the same synergies or the same outcomes.

3. What collective capability it has – the *shared repertoire* of communal resources (routines, sensibilities, artifacts, vocabulary, styles, et cetera) that members have developed over time.

We submit that a community of practice naturally emerged and was purposely formed in 2000 as an outgrowth of ASEE Graduate Studies Division meeting held in St Louis. The intent is to address the transformation of ETL graduate professional education. Through the active participation of a core group representing higher education in the USA and abroad, the community of practice has been actively engaged in problem-identification related to ETL graduate professional education. The community of practice has been sharing resources and experiences from jurisdictions throughout the North America. Additionally, it has been discussing options for creating a collaborative, electronically-mediated infrastructure that would enable an ETL community of practice not only to exist and but also to flourish. Bottomline, this community of practice has been engaged in capacity building to respond to challenges within individual institutions and communities that, as lone higher education practitioners, would be difficult and isolating.

The ETL community of practice embraces the sharing of knowledge across institutional, disciplinary and sectoral boundaries. Shared knowledge and insights generated through the ETL community of practice are oriented towards individual and organizational learning[31] by way of intelligence gathering (focus on the past), experiential learning (focus on the present), and experimentation (focus on the future) in support of state-of-the-art ETL graduate professional education program development. There is mutuality which enables ETL community of practice participants to dramatically increase the rate at which they learn to re-engineer ETL graduate professional education programs and engage in new professional education model development at the individual institutional level, while contributing their individual and institutional knowledge and insights to the collective. This approach embraces new models of knowledge management in higher education program development. It moves away from the old industrial economy paradigm of knowledge = power, so hoard it, to a new knowledge society paradigm where knowledge = power, so share and it multiples.[32]

5. Unanswered Questions and Implementation Challenges

Re-engineering ETL graduate professional education models in higher education represents a radical rethinking about graduate program development. It requires an education marketing orientation that address basic marketing questions such as:

- What is our market, and what makes it fundamentally different from the target market for either MBA programs or research-based graduate engineering science programs?
- What career-related ETL product(s) does the market want?
- What price is the market willing to pay for new learning products which fundamentally meet their needs?
- What can we deliver vis-à-vis "total product," based on what the market is willing to pay?
- What are the most effective and responsive delivery strategies and under what circumstances?
- How do we promote ETL graduate professional education as a "new product introduction" that meets an increasingly unmet stakeholder community need, without disenfranchising the established interests manifested by the science-driven, basic-research culture in higher education?

ETL also requires a program development policy, which addresses such questions such as:

- What are the demands of ETL practice that arise out of social, economic, technical and political forces?
- What do responsive models of graduate professional education "bring to the table" by way of complementing the existing science-driven, basic-research models of graduate education?
- How can the delivery of graduate professional education be organized to move beyond the basic provision of instruction to the facility of relevant learning and development that supports enhanced competence and performance?
- How can innovation at the program level be demonstrated when there are often significant institutional structural and cultural barriers to re-engineering for responsive ETL graduate professional education?

These represent some of the most daunting, early implementation challenges the ETL community of practice has identified. A key strength of the ETL community of practice is that collaboration at the inter-institutional level represents an environment where addressing these questions collectively means that individual program leaders with the foresight to see future issues and demands no longer have to feel like "lone voices in the wilderness."

6. Conclusions

Higher education is generally compelled to rethink its roles, responsibilities and relationships with its stakeholders. Within the domain of higher education, providers of ETL graduate professional education and continual professional development have ample opportunity for new learning product and service development that is closely aligned with actual innovative technology development.[33] However, there remain serious structural and cultural barriers at the higher education institutional and sectoral levels that must be addressed to enable pathways for the evolution of responsive ETL graduate professional education.

Established higher education institutions that are interested in surviving and thriving in light of emerging societal challenges must re-examine their program development practices. The ETL community of practice that emerged out of the 2000 ASEE Graduate Studies Division meeting represents an innovative response, enabled by converging communications technology, for otherwise isolated educators to collaborate on new directions for ETL graduate professional education. Collaboration has led to early and promising insights, as well as the exploration of collaborative, action-oriented responses, for meaningful learning supports to serve ETL professionals who are also compelled to continually learn and change in response to profound and ever changing practice demands. In this sense, higher education can play proactive and constructive engagement roles in addressing pressing societal needs.

The significance of re-engineering graduate professional education based on an engagement paradigm is transformational. The collaboration among ETL community of practice participants has had, and will continue to have, a profound effect on ETL graduate professional education. In today's global, competitive academic environment, we are challenged to continually re-invent ourselves based on responsiveness to societal needs. Institutions of higher education and can no longer ignore the importance, impact, and validity of engagement-based models of graduate professional education, such as the one that has been developed at Purdue University and validated by its stakeholders. The collaborative mission of the ETL community of practice, then, is to:

- ✓ Redefine graduate education,
- ✓ Leverage and engage all institutional resources,
- ✓ Share programmatic, operational pedagogical and curriculum ideas,
- ✓ Increase economic and public policy impact for society,
- ✓ Demonstrate outcomes by actual graduate professional education program delivery and assess feedback, and
- ✓ Provide a venue for all engineering and technology graduate programs to substantiate their creative problem-solving process for business, industry and government agencies by providing master's and doctorate level education.

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