REENGINEERING Ph.D. PROGRAMS

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Abstract

Recent articles by John A. Armstrong, “Rethinking the Ph.D.” [1] and Phillip A. Griffiths, “Reshaping Graduate Education”, [6] prompt faculty and administrators responsible for graduate education to study and implement changes that are needed in our programs. An analogy is drawn between the issues proposed by these articles and deep-rooted problems targeted by Michael Hammer’s and Steven Stanton’s [9] in the "Reengineering Revolution” and Hammer’s and James Champy’s justifications for "Reengineering the Corporation” [8]. Although Hammer and Champy's concepts are often controversial in the corporate world, they have attracted widespread attention, and many followers have achieved institutional revitalization. Armstrong and Griffiths make strong arguments for change, and the Hammer, Champy, and Stanton’s concepts offer a viable methodology for attack.

The Reengineering Concept

Michael Hammer states that reengineering is clearly an idea whose time has come. Hammer considers reengineering as a revolution and defines it as, “The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in performance.” [7] His performance measures include cost, quality, services, and speed. Reengineering has emerged from the TQM philosophy as a means for improving processes. TQM assumes that the process is basically sound and that necessary continuous incremental improvements can be achieved through a structured approach to problem solving and an unfaltering commitment of informed leaders. However, reengineering digs deeper by challenging the fundamental process and questioning why it should even be sustained.

Today, the term “reinvention” is too often used interchangeably with reengineering; Hammer’s early concepts of reengineering may better reflect today’s concept of reinvention [5]. Reinvention is unquestionably dramatic and radical and challenges the fundamental process; it requires a bold and complex restructuring for a solution and/or major process substitutions. Most corporations which have embraced the reengineering concept have studied the option of radical restructuring as proposed in Hammer’s 1990 title, but most often accept and implement the less-radical modifications required to achieve significant gradual improvements and substitutions in the macro process [5,10,11].

David A. Garvin, through a roundtable discussion, approached reengineering by leveraging the processes for strategic advantage [5].

> Reengineering efforts are sweeping the Country as companies shift from purely functional organizations to those that better accommodate horizontal work flow. The critical questions involve strategies and management practices. Which strategic proposals are best served by the processes? ---
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> Jan Leschly, CEO of Smith Klein Beecham, a roundtable participant led by Garvin stated:
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> process improvement is not limited to large-scale reengineering or fixing macro processes. Real power comes rom working with small processes --- that’s where the inefficiencies are.

In applying the reengineering concept to graduate education in this paper, Leschly's concepts are deemed to offer the most appropriate focus. Paraphrasing for our focus, “real improvement comes from working with small processes --- that’s where the corrections need to be made”.

The traditional Ph.D. process in U. S. universities is an integration of (a) a block of academic courses, (b) literature reports, (c) academic work experiences, and (d) an original basic-research dissertation. At the offset of this paper challenges by respected leaders of the traditional process have been recognized. However, since the macro process has been proven highly successful in most respects the conclusion is that, radically displacement is unnecessary and ill advised. In response to Armstrong and Griffiths' deep concerns, the process must be studied and perhaps modified to meet better changing customer needs and other contemporary requirements. Significant and tangible incremental changes in the macro process by altering small sub-processes are deemed essential to achieve continuous improvements and provide high quality services to customers of all types. Customer demands are changing rapidly and the macro process must be sufficiently flexible to accommodate these promptly and effectively.

Vice President Gore’s commitment/assignment to “reinvent the government” might better be described according to more recent concepts as to reengineer the government to achieve incremental and small process changes in efficiency and better customer services. Hammer’s 1990 radical and dramatic approach does indeed attract attention, but has the serious danger of threatening the very existence of proven macro processes which in reality need only to be modified and/or restructured -- not replaced. The U. S. government does not need a revolutionary change which could destroy proven processes, but rather in-depth incremental improvements and sub-process substitutions necessary for efficiency and better service to customers (citizens, especially taxpayers).

In the context of this paper the term reinvention is reserved to describe the dramatic and radical and will not be pursued further in addressing changes in graduate education. The version of reengineering discussed and applied is that which challenges and assesses the macro process and makes significant sub-process substitutions and incremental changes for a graduate program or an institution to better serve customers. Reinvention and Hammer’s early definition of reengineering are deemed unnecessarily dramatic and radical for correcting the recognized problems of graduate education. However, significant and tangible restructuring to permit more diversity and focused customer service are deemed essential.

Arguments for Revitalizing the Ph.D

John A. Armstrong recently retired as IBM's Vice President for Science and Technology and his article reflects the corporate viewpoint. His article, “Rethinking the Ph.D.” is adapted from, “What Is A Science or Engineering Ph.D. For?” --- A lecture he delivered at M I T in November of 1993.

> The upheaval in east-west relations and the rapid transformation of global markets have stimulated a fundamental reexamination of U.S. science and technology activities.
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> So far, however, there has been little serious reassessment of the underlying assumptions, expectations, and requirements of Ph.D programs in science and engineering.

Phillip Griffiths is Director of the Institute for Advanced Studies in Princeton, N. J. and is Chair of the National Academies’, (NAS, NAE, NIM) Committee on Science, Engineering, and Public Policy, (COSEPUP). His article reflects the deliberations of the Committee.

> Ph.D. training must change to prepare students for jobs they are likely to find. The U. S. system of graduate education in science and engineering is one of the nation’s great strengths. It has served as an international model ----- But changes in the way science and engineering are conducted and funded are exerting stress on the traditional system of graduate education. The end of the Cold War, the rapid growth of international competition in technology-based industries, and a variety of restraints on research spending have altered the needs of employers and the patterns of employment for scientists and engineers. This particular ASEE audience is especially interested in graduate education for scientists and engineers, but all Ph.D. programs must be assessed in the context of changing world conditions and job markets, and be altered accordingly. The traditional programs have and will continue to be effective in producing Ph.D.s for academe, national laboratories, and

basic research in industry, but the future demands for these traditional graduates will decrease more before a plateau is reached. Reengineering, as defined in the context of this paper, does not advocate the elimination or radical change of the proven U. S. Ph.D. macro process, but rather necessary adaptations and sub-process substitutions to achieve flexibility and diversity necessary to serve all future customers well.

If broad customer expectations and demands are not met adequately, many graduates of traditional Ph.D. programs will not find employment. The Nation must have an increasing number of highly-educated scientists and engineers, but the expertise of many has to be focused on strategic national needs rather than totally on traditional values. Griffiths' article was based on the COSEPUP report of the National Academies, and emphasized that to meet the expectations of most employers, graduates have to be trained in broad areas especially communications, team work, and finance. These concepts are now emphasized in master of science programs in engineering management in many universities. A stronger emphasis on design, the practice of engineering, and management is encouraged for most graduate programs. These goals are being pursued presently at the masters levels in many graduate programs, but not broadly or significantly at the Ph.D. level.

The exception is at the very few universities offering a Ph.D in engineering management. Perhaps as a start for reengineering Ph.D. curricula an increased number of graduates from engineering-management Ph.D. programs should be produced since they are expected to be highly welcomed by employers in the new environment described by Armstrong and Griffiths.

However, reengineering to achieve adequately the objectives of Armstrong, Griffiths, Bloustein, and others is not simply providing a limited focus on engineering management Ph.D.s only, but more broadly a redirection and restructuring of the macro process for all technical/scientific curricula/programs to provide options and diversity. Flexibility for all Ph.D programs, even beyond science and engineering, can enable the selective inclusion of a diversity of courses, and if strategically planned substitutions will not erode traditional quality.

Many new Ph.D. graduates in engineering and science will be needed in the interdisciplinary fields of product development, design, health care, environmental protection, urban planning and development, manufacturing, and public service. Are U. S. graduate schools prepared to provide course flexibility and interdisciplinary Ph.D. programs to meet this envisioned demand? Probably not without reengineering the process!

A Practice-Oriented Option

The Ph.D. in engineering management offered by a few universities is one approach to a practice-oriented Ph.D. to meet some of the future needs of employers. However, much broader reengineered objectives are deemed most promising and can be achieved by sub-process substitutions. One example is a program which substitutes a high-level design or engineering project, or a complex case study, in industry or a government laboratory for the traditional basic-research dissertation. This substitution would not necessarily require any change in the course work specified.

While Chancellor of the University of Missouri-Rolla, with the encouragement of regional high-tech employers, I proposed to the engineering faculty a doctor of engineering as an alternative to the Ph.D. Only the departments with an established Ph.D program were to be eligible to offer this option. This restraint was effective in responding to critics that quality would be eroded. The faculty approved the degree after in-depth deliberations and it was then submitted to the Board of the University System, about 1970, and approved as a customer oriented doctoral option. I am uncertain of the status of the degree-program at this time, but the concepts seem clearly in keeping with the present arguments of Armstrong, Griffiths, and Bloustein [1],[4],[6].

Reengineering the process with this sub-process substitution would not necessarily require a special designation of the degree, but the structure and content for this and other program options must be clearly specified, strategically planned, and well understood by both faculty and employers.

According to Armstrong, increased attention must be paid to research in the so-called strategic areas, those that are most likely to help the Nation achieve its economic or environmental goals. He recognizes that educators consider changes to be delicate. He proposes that instead of cloning their faculties, science and engineering graduate schools should be preparing their Ph.D. students for a variety of possible roles. Basic research expertise is essential but this

alone is insufficient for our society to achieve its economic and environmental goals since R&D represents less than 5 percent of the process by which wealth and jobs are created.

Outside Work Experience

Another example of a micro-process substitution to address contemporary needs is adding work experience outside of academe. Also, a shorter study period to complete the macro process is highly recommended. The internal academic work experience today is too often a repetition of a one year's experience rather than a sequence of new and diversified multi-years of experiences.

Armstrong recognizes that the U.S. currently enjoys world leadership in many areas of research and must be careful to preserve this advantage, however, we need to address deficiencies in our national performance in the 95 percent of wealth-creation that is not R &D. The substitution of an in-depth report of a high-level design or engineering project, or a carefully structured case study, for the basic research dissertation is not considered radical, but provides a tangible process modification commensurate with the concepts of reengineering. Griffiths, Bloustein, and Armstrong's arguments support this option along with flexibility in selecting the block of courses and adding work experiences outside of academe.

Ethics and Public Policy

Engineers and engineering managers have a strong sense of responsibility to develop products and make decisions that are highly beneficial to society [2],[3]. They also have an admirable propensity to adhere to prescribed ethical codes of the profession. However, the need for a higher level of societal concern and public responsibility is now emerging with increasingly sophisticated high technology products and services. Providing these special courses in graduate curricula constitutes a third micro-process substitution to help engineering managers and engineers develop a better understanding of the role of technology in shaping public policy, and developing a moral-reasoning process. These experiences sharpen practitioners' capabilities and sensitivity for decisions to serve better the public interest at the highest possible level.

Engineers are often the experts for determiningg risks involved with a product, service, or system, but typically do not exert a strong influence on decisions of non-technical managers. Masters of Science in Engineering Management curricula strive to combine engineering expertise and management skills so that the conservatism of engineering is given a heavyweight in management decisions if significant risks are involved. Courses in ethics and pubic policy in the curriculum for engineering management, technical engineering masters programs, and restructured Ph.D. programs are expected to instill in graduates broadly a greater sensitivity to risks, societal values, and a persistence to resist diligently high-risk management decisions not adequately supported technically.

An ethical and public interest question often asked is, "whether or not to deny the public the benefits of an attractive product or design while its safety is being proven beyond a reasonable doubt". Engineers and scientists don't have all the technical answers, but their expert know-how qualifies them to make fair and ethical decisions in the public interest. In fact, they have the professional responsibility to be assertive when technology is a predominate factor. A justifiable lingering public concern is that engineers and scientist, especially Ph.D.s, may not be highly sensitive to ethical, policy, and other societal issues. The author holds the viewpoint that this essential sensitivity can be catalyzed by introducing courses in ethics and public policy in all graduate curricula at both the masters and Ph.D. levels, and that society will benefit significantly from these inclusions.

Education, Industrial, and Government Partnerships

Edward J. Bloustein, President of Rutgers University advocated the second land-grant revolution at the 1987 NSF Conference, "Industrial Science and Technological Innovation", Georgia Institute of Technology. This address recognized at an early date many of the changing needs of employers for Ph.D.s expressed more recently by Armstrong, Griffiths, and others.

In his introduction, Bloustein cited Lincoln's commitment to the economic future of our young nation by his signing into law the Land Grant Act in 1862 which provided for our network of agricultural and mechanical colleges.

> Now, [more than] 100 years later, we are witnessing what I have come to think of as the second land-grant movement, the post-industrial land grant revolution. Like the first such revolution, it too, has come swiftly and has begun to touch Americans everywhere and every day. Like the first, it too rests on a radical transformation of many of our institutions of learning. Like the first, it too involves a cooperative effort of the federal and state governments, as well as of the private sector of American life. And, like the first, it too involves a new form of technology transfer, anew way of bringing the lessons of the library and the laboratory to bear on the economy of the nation.

According to Dr. Bloustein the "second land-grant revolution" will reflect the economy and politics of the late twentieth and early twenty-first centuries. Institutions of higher education have now become central to the post-industrial phase of economic development and world politics.

Dr. Bloustein offers a challenge to faculty and administrators to respond to new demand in higher education in research, education, training, and national involvement. The reengineering of Ph.D. programs proposed in this paper is not only prompted by changing national priorities and employer needs, but also to heed the recent challenges of a visionary educator for creating essential partnerships. Ph.D. programs must be reengineered to promote partnerships focused on strategic national problems if the Nation is to prosper in the highly competitive international marketplace, and if the quality of life for all citizens sustained and enhanced.

Conclusions

Our graduate programs must be revitalized to meet adequately the changing needs of students and employers and the strategic priorities of the Nation.

The macro process for Ph.D. programs is proven to be sound, but it must be reengineered to provide essential diversity and continuous improvement expected by customers with rapidly changing demands.

Tangible improvements in the macro process must establish programs providing for a greater diversity and matrices defining interdisciplinary focuses. Also, the structure must be strengthened for addressing national strategic issues, ethics, public policy, management, economic and environmental security, and the option to substitute an in-depth report on a real world case study or design project for the traditional basic-research dissertation.

Ph.D. programs must give more emphasis to communications, teamwork, and finance and provide a foundation for interdisciplinary fields of product development, design, health care, environmental protection, urban planning and development, manufacturing, and public service.

Desired small process substitutions include (a) flexibility of courses specified, (b) work experience outside of academe, (c) an option for substitutes for the basic-research dissertation, (d) more diversity in literature reports including ethics and public policy, and (e) a strategically planned and customized reduced period of study.

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