Creating an Environment for Lifelong Learning

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Abstract: Learning is a continuum, without beginning or end. As applied to product and manufacturing engineering, learning must be a matter of the routine of professional life. In the ideal learning spectrum, university education would form the foundation for professional understanding and continuous investigation. Each university degree would be an identifiable platform from which to launch acquisition of the in-depth command of subject matter which is the hallmark of the finest in engineering practitioners. In current reality, however, it is observed that the typical university experience is separate and distinct from the professional workplace. Academic focus and industrial reality are not well-matched. This paper will explore possibilities for creating an environment where academic and experiential learning can be effectively and efficiently co-mingled through partnering between academia and industry. The objective of such partnering is an intellectual environment wherein academic rigor is learned in concert with professional job performance and where academic complexities are addressed within the industrial concern. The authors draw upon partnership experiences in which they are engaged and extract some critical parameters which are necessary for an effective lifelong learning environment.

Voice of the Customer: At the dawn of the twenty-first century, industry in all corners of the world are fully embedded in the Knowledge Age. In this environment, competitive, business and financial advantage for the industrial firm derives from the knowledge -- and the continued learning -- of its workforce. [1] Nowhere has the validity of this concept been demonstrated in as dramatic a fashion as in the securities markets, where the market capitalization of Microsoft has exceeded that of General Electric and General Motors, with only a fraction of the traditional capital assets. [2] Other noteworthy examples of the high valuation placed on knowledge-enterprises include America Online, Oracle and Yahoo. Valuation levels throughout the NASDAQ confirm the high financial worth of technology and knowledge in the marketplace at the turn of the millennium.

A new class within the workforce has been identified as 'knowledge workers', people whose primary function in the business enterprise is the application of information and knowledge. In the manufacturing sector, for either hardgoods or softgoods, the key knowledge workers are engineers, whose knowledge has an ill-defined, but well-accepted, half-life. Engineers must

continually learn in order to stay abreast of the technologies that impact their jobs. It is the sum of its engineering knowledge that represents the 'knowledge value' of the business enterprise, and this asset must be continually replenished and expanded in order that the business value is not eroded. [3] In manufacturing industries, we are rapidly approaching an era where quality and price will no longer be adequate to differentiate products in the marketplace. These are becoming givens -- the price of admission to the business. If products lack quality or if their prices are a bit high, they will simply fade from view -- victims of more agile and aggressive competitors. The only effective differentiator for manufacturing enterprises has become its human, intellectual capital -- the sum of the understanding, skills and competencies of its technological workforce. [4]

	Market Capitalization (billions of dollars)
Microsoft	345.8
General Electric	339.3
America Online	71.0
Ford	70.9
General Motors	46.8
Oracle	42.4
Boeing	32.6
United Technologies	24.5
Yahoo	23.6

Figure 1: 1998 Year-end Market Capitalization of Selected Corporations [2]

Despite all of the power emanating from the cumulative knowledge of the workforce, for the majority of business enterprises, lifelong learning of the workforce has not taken its place as a critical and accountable component of business strategy. Knowledge generation remains a secondary factor in the celestial sphere of general business strategies, rather than a first-line issue of critical importance. In most enterprises, training, education, research and development, laboratories, technical conferences -- sources of continuing learning -- retain the image of frills or extras or perquisites, something done when there are funds not needed for something important.

While some of this shortfall may be attributed to the short-term thinking characteristic of the typical corporation, other -- perhaps more fundamental -- reasons may be equally influential. Even casual observers of education -- i.e., structured learning -- quickly note that we commonly and pervasively think about learning as having definite starting and ending points. From kindergarten through graduate school, the language applied to education and learning is bounded by beginnings and completions. The lexicon reflects a built-up chasm between learning (what happens during defined periods of enrollment in a specified curriculum) and working (what we do in 'the real world'). This is a separation that society can no longer afford. And it is an artificial differentiation no longer needed.

Relevance and Cogency in Engineering Education: Examination of a conducive environment for continuous learning begins with restatement of some well-worn, but sometimes mislaid, truths. Learning is a key part of life. Accumulation of knowledge occurs all the time -- in the workplace as well as in more traditional 'educational' settings. The objective in the Knowledge Age is to recognize, organize and capitalize upon this very basic notion.

When properly done, formal education provides the fundamental knowledge critical to engineering, in general, and to a specific engineering discipline. Further, the best formal curricula will assure that foundational skills for continuous investigation and experimentation are mastered. The challenge in formal education is to achieve the objectives of fundamental scientific knowledge, plus its application in the workplace, plus broad understanding of the selected engineering discipline, plus in-depth mastery of at least one engineering specialty, plus cross-discipline learning and depth in the 'soft skills', plus developed capacity for continuing learning. A formidable task, to be sure, but the task nonetheless.

The current reality is that industry perceives a shortfall in the undergraduate preparation of engineers. The recent landmark study by the Society of Manufacturing Engineers collected data from dozens of engineering managers in six major industries. The vast majority believed that freshly graduated engineers were not well-prepared for "... real world engineering applications". Gaps in competencies were identified in a very wide array of topical areas. These coalesced into five general groupings: skills in communications and teamwork; abilities to apply statistical thinking and scientific first-principles to specific real engineering problems; deep and detailed understanding of the principles, processes and tools of modern manufacturing; appreciation for economic and business factors in engineering; skills for managing change and for continuous learning. [5] While this study was specific to the discipline of manufacturing engineering, it is arguable that the same critique, with modified terminology, is applicable to all fields of engineering.

The challenge in lifelong learning will vary somewhat depending upon the career path -- as a technical specialist, operations integrator or technological strategist. The learning needed will be furnished from many sources -- formal post-graduate education, short courses and seminars, professional conferences and workshops, and critically, structured learning on the job. [6] Learning is a vital responsibility in every engineering job description. The learning task has several components: strong preparation in undergraduate formal education; career-path focus and direction; a conducive learning environment in the engineering workplace.

It appears at times that the gaps between needed capabilities and real preparation of fresh engineering graduates has occurred just at the time when leading-edge knowledge has become an urgent business imperative. Corporations seem pressured to supercharge knowledge growth within the workforce at the same time as new graduates are falling short of expectations. These perceptions are reflected in increasing competition for established professionals with proven skills.

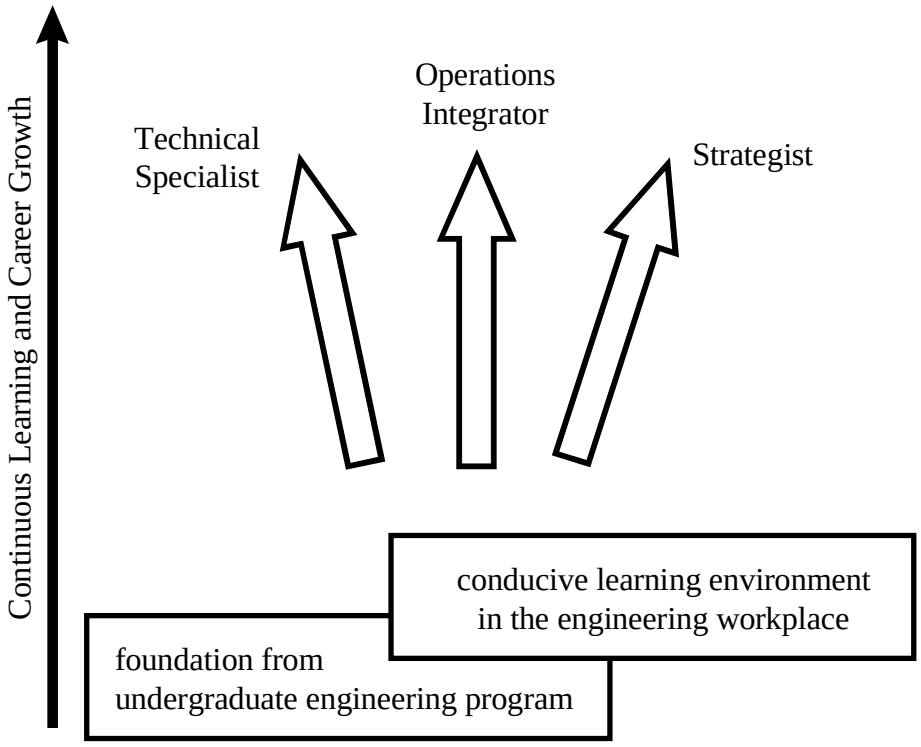

Figure 2: A Map of the Lifelong Learning Task

However, many large industrial firms have responded to the 'knowledge squeeze' by creating internal 'corporate universities'. One of the persistent justifications for the large investments in a corporate university revolves around the constant tension between theory and practice. Life on the factory floor is the essence of practicality. Product must be produced -- within quality specifications, within affordable cost and time constraints. The engineer's central focus is to solve problems -- to clear the way. Over the last four decades or so, engineering education has moved from its practical roots to a theoretical focus. Mathematical models replaced laboratory apparatus. Graduates became more proficient in mathematics and science, while hardware experiences in shops and labs largely disappeared. Thus, while newly graduated engineers might have strong analytical skills, their shortfall in practical application has been recognized by large corporations and addressed through internal training. As needs of the business enterprise have intensified and as gaps in capabilities of graduates have persisted, company training programs have grown and matured. Course catalogues, syllabi and administrative structure in many corporate training departments are now recognizable as those of a university.

While the corporate university is probably an irreversible phenomenon, it is important to the economy and to society at large that we not fail to glean full advantage from the massive learning infrastructure represented in colleges and universities. If we take the premise that learning is indeed a continuum and that formal education lays the foundations for a career of learning, the core questions transform from the need for career-long acquisition of knowledge to methods for nurturing continuous learning: how to improve relevance of formal engineering

education -- how to improve the linkages between formal education and career learning -- how to improve the flow of information between the academic community and the factory.

Industry- University Dialogue: The most glaringly obvious -- and most critical -- activities that can be undertaken to improve the flow of information between academia and industry are those that increase the frequency and cogency of the dialogue. When a university professor investigates theories or models of production, the research would be very much enhanced by regular dialogue with practicing engineers facing the same sort of problems in a factory. The converse applies as well; enlisting the assistance of a good theorist from a university often will offer great promise to industry teams struggling to solve real production problems. Introduction of these real problems into the educational stream would begin to address some of the competency gaps which have been identified in the recent SME study, as well as elsewhere. [6]

The key to this sort of exchange is that both groups come to speak the same language. One of the most troubling aspects of the engineering professoriate in the past several decades has been the dearth of professors who have actually practiced their engineering specialty 'in the real world'. The obvious best way to address this issue is to create an environment where communications flows between factory and campus -- where relevant knowledge and practical utility merge. Numerous means have been devised in a number of locales to foster open and lively dialogue.

Many universities and corporations have employed a variety of means for promoting vitality in cross-organization dialogue, and these are operated with varying degrees of formality and effectiveness. Most activities of this sort coalesce into three general areas in common interest: instructional materials; personnel exchange; projects and research.

- Class and laboratory exercises conducted at a plant location
- Laboratory and classroom projects supplied by industry
- Summer internships for faculty in industry
- Employment of industry experts as adjunct faculty
- Temporary exchange of university and industry personnel
- Joint authorship of case studies with joint reviews of results
- Partnering on experiments in advanced technology
- Industry sponsorship of applied research projects on campus

Figure 3: Examples of Industry-University Dialogue

It has become most common that industry -- in virtually every engineering discipline -- is the leader in new technology, apparatus and applications. Laboratory apparatus on campuses is often one-to-many generations behind the current industry standard. In that industrial observers, in the SME study and elsewhere, express concern over gaps in the experience of new graduates with current technology, it becomes more and more obvious that an important part in the solution of this particular piece of the problem is readily at hand in making state-of-the-art

apparatus and applications of technology available, either in the factory or on campus, to students in partnering universities.

Similar enlivenment in the undergraduate learning experience can also be derived from another easily initiated practice -- exchange of personnel. In that engineering faculties are sometimes faulted for lack of 'real world' experience, industrial firms interested in addressing this issue can offer summer internships or sabbatical appointments to faculty. In the other direction, practicing engineers and technical managers are often well-equipped to teach in both undergraduate and graduate curricula. Corporations wishing to improve industry-academy dialogue will most often find a significant return in terms of increased relevance of academic curricula from investments in faculty internships and in release of key managers and engineers for adjunct teaching assignments. [7]

Perhaps the most conventional means of interaction between industry and academe has been the corporate sponsorship of academic research. In today's more focused and competitive world, commercial relevance of such projects has become increasingly important. In order to address both commercial relevance for the corporation and curricular relevance for the university, such projects should perhaps be better structured as joint efforts between specialists from both the industrial and academic participants -- and crafted to include participation by students in every way possible.

Habits of Effective Learning: Regardless of the specific activities which are pursued, the primary focus must be on creating an environment which is conducive to continuous learning. In this, there are two key issues: development of habits of continuous learning during the undergraduate experience and positioning engineers in a workplace that is equipped with policies and practices that stimulate learning.

A recent excellent study of characteristics of life long learning conducted at Brigham Young University collected data from over 450 graduated engineers and their supervisors. This investigation sought data and understanding about the attributes and attitudes that most favored effective continuing learning by the working engineer. The focus was on assessing personal and interpersonal features of the work and learning environment, rather than on identifying specific activities or policies that could be employed to promote knowledge growth in the corporate enterprise. The factors probed related to fundamental intelligence, formal post-graduate education, technical preparation and experience, 'people skills', and personal attributes. The study sought to assess the feelings of the graduated engineers as to what they believed to be the most important attributes for life long learning and how they perceived the effectiveness of their undergraduate education in preparing foundations in these attributes. The research also probed how the working engineers perceived that their companies valued each attribute and asked the engineers' supervisors to make the same assessments. [8]

All of the surveyed groups in the BYU study rated the attributes of 'adaptability to change', 'desire to learn' and 'good thinking skills' as the most important personal qualities for life long learning. Other personal attributes that were rated with differing degrees of importance by the three measures used in this research included 'ability to work with people,. 'technical

preparation', 'values', 'intelligence', 'technical experience', 'professional participation' and 'post-graduate degrees'. [8] Of those characteristics deemed, in this study, as important to continuous learning, only technical content of the curriculum and offering of graduates degrees are subject to direct approach. All of the other characteristics relate far more to how faculty teach, rather than to what is taught.

This research suggests that innovation in teaching ought to be given a higher priority in the university. Specific means through which to foster these habits of learning in the undergraduate engineering curriculum is an issue worthy of substantive examination. While there will be many different and disparate means, it is suggested that additional attention to these issues is needed, and that this topic merits high priority from faculty and their industrial advisors.

A Conducive Learning Environment: In the corporate setting, an environment conducive to effective continuous learning is also created more by how things are done than by specific policy initiatives or sponsored activities. Three different strategic styles have been identified to foster learning throughout the organization. In a 'coincidental or accidental' strategy, the organization eschews labels and slogans. These organizations do not consciously or conspicuously set out to become 'learning organizations'. Rather, they create a focus on getting things done and on doing the right things to gather the resources and knowledge to accomplish defined objectives. More commonly, an 'overt' strategy is adopted, where the organization consciously adopts one of the many highly publicized methodologies which have been crafted by successful consultants to systematically encourage learning throughout the workforce. More subtly, an organization can follow an 'influential' strategy, where the leadership provides example, encouragement, recognition and tangible support for learning. [9]

However a proper environment is created, there are several features that are evident as important for encouraging and reinforcing effective continuous learning throughout an organization.

1. Define and understand the strategic role of knowledge in the enterprise. [10] Assure that everyone in the workforce understands how knowledge and learning contribute to the success of the enterprise.
2. Identify and/or invent metrics. The organization and all of its people must understand how 'success' is measured. Provide a clear view of what visible evidence indicates that learning is being accomplished to fulfill the knowledge strategy.
3. Identify and share best practices. [10] There will always be far too much to be accomplished. Being able to learn from others how to learn better is a great advantage.
4. Treat education and training of the workforce as an investment. Channel investment funds to areas where the enterprise most needs knowledge. Build knowledge before it is needed. Build a routine of learning through the workforce. Build a sense of pride in and responsibility for learning.
5. Eliminate fear of mistakes. [11] The old saw is still apt: "If you're not making some mistakes, you're not trying hard enough."
6. Foster an appreciation of learning from others. [11] Copy success. One of the most counter-productive habits is the 'not invented here' syndrome.
7. Match rewards to organizational objectives. Reinforce achievements in desirable areas. If, for example, customer service is something desired by the enterprise, include learning how

to better serve customers in the salary and bonus reviews for individuals who interact with customers. In universities, if good teaching is an objective, measure it and reward professors for it. Continue to reward those who continue to learn how to teach better.

8. Foster an atmosphere of sharing. [11] Teaming has become a critical organizational asset in commerce and industry. Provide recognition and reward for success in joint efforts.
9. Insist on breadth of knowledge ownership. [11] Don't rely on one or a few key people for knowledge that is critical to the organization's continuing vitality.
10. Allow people to use the knowledge they have acquired. Perhaps this should be phrased more as 'encourage' or even 'require', rather than 'allow'. It is a decidedly human trait to want to use newly acquired skills -- to be excited by trying out the new things you have learned. Being in a position to demonstrate new skills is also a very powerful incentive to keep on learning.

There is an important message for colleges and universities buried in the preceding dialogue. All of the discussion about knowledge, learning and enterprise value is entirely neutral in the matter of sources of knowledge and skill. It is apparent that the knowledge needs of industrial and commercial enterprises are not defined by what is available in the traditional catalogue of higher education. Universities are now in a competitive environment. This provides both opportunities and challenges. Ultimately, all of us in the technology fields are sailing in the same boat. Whether in an academic setting or in a manufacturing plant, we must learn how to help each other learn the valuable lessons that create competitive producers -- and we must put into place an environment where learning never ends.

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