THE SYMBIOTIC AND SYNERGISTIC RELATIONSHIP
BETWEEN INDUSTRY AND UNIVERSITY

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SUMMARY

This Paper explores the symbiotic and synergistic relationship between Industry and University. The first section describes the relationships and connections between Industry and University. The second section looks at the changing Industry contexts & settings, on the one hand, and the needed engineering education paradigm – shifts, on the other.

1. INTRODUCTION

It is increasingly being recognized and acknowledged that industry and university are co-producers of engineering capabilities. Industry has the responsibility to continuously adapt the existing engineer knowledge and skill profiles to new demands and requirements; in addition, Industry must generate those skills and abilities that can not be taught and learned in the University, but are acquired solely through experience in real-life settings. Universities bear the responsibility of translating new knowledge and skill demands on engineers into re-designed engineering curricula, and of providing new generations of graduates with the competencies required in the XXI century. At the two trans-Atlantic US-German Conferences, “Engineers in the Global Economy” in the US, and “Innovative Engineering Education – Higher Education Facing Globalisation and Technological Change” in Germany, there was consensus among the participants that the challenges confronting the engineering professions can not be mastered by one side alone [1]. They demand cooperation between Industry and University that extends beyond their traditional division of responsibilities, through joint or dual education programs and strategic partnerships, or through a stronger integration of initial and continuing education.
SECTION I: THE INDUSTRY-UNIVERSITY CONNECTIONS

2. SOME MUTUAL DISSATISFACTION [2]

Table I describes the feelings of mutual dissatisfaction of Industry about University, and vice versa.

3. COMPLEMENTARY ROLES FOR UNIVERSITY AND INDUSTRY [2]

Tables II and III describe the complementary roles for University and Industry, highlighting their individual strengths or resources and requirements.

4. CORPORATE DEMANDS AND INSTITUTIONAL RESPONSES [1]

Table IV summarizes the corporate demands on engineers and assessments of engineering capabilities, and the responses by higher education institutions to new demands on engineers.

5. THE CULTURAL DIFFERENCES BETWEEN UNIVERSITY AND INDUSTRY [2]

Table V captures the differences in perceptions of University and Industry.

6. THE MARRIAGE BETWEEN INDUSTRY AND UNIVERSITY

Industry and University are such ‘eligible’ partners, it may be asked why the Marriage doesn’t take place. Maybe they are too young (relatively speaking) to feel the love and passion! Maybe we need a matchmaker. Maybe we need to let them get acquainted and become friends.

Clearly, each must be attracted to the other. Both must appreciate their complementary strengths and needs. There must be a high probability of useful results achievable in a reasonable period of time. There must be champions on either side, who have understanding and commitment.

It is often true that Industry is an unwilling partner - Industry attaches more value to time and timeliness, and unless the potential of success is high, it will hesitate to commit time and effort. University must approach Industry with a ‘dowry’ – commitment and speed.
7. MULTIPLE MODELS OF PARTNERSHIP

There are many different modes and models of University-Industry-Government-R & D lab cooperation, collaboration and partnership. Figure 1 illustrates some of these permutations and combinations, including some examples.

SECTION II : CHANGING INDUSTRY CONTEXTS AND SETTINGS AND THE NEEDED ENGINEERING EDUCATION PARADIGM-SHIFTS:

8. THE NEED FOR A CHANGE IN THE ENGINEERING EDUCATION PARADIGM [1]

Tables VI and VII (a and b) describe the restructured work contexts of Engineers; and the new skill requirements on Engineers.

9. THE TRANSFORMED CORPORATE SETTING OF ENGINEERS’ WORK [1]

Beginning with the Information or Knowledge Revolution, engineers find themselves working in a wide and heterogeneous spectrum of organizational settings and work situations. The work situations, and consequently skill requirements, vary across: different specializations (e.g. mechanical vs. software engineers); with the R&D content of their job assignments; and with company size and the intra-company division of labor.

Depending on their position within the value chain, engineers are required to have a solid scientific and theoretical knowledge base, or more of applied skills and talents. The classical ‘researcher-type’ engineer, designed to suit the large-scale industrial labs of the post-war era, has no future in the emerging scenario. The needs of small companies, especially those in more traditional technology fields, by contrast, focus on the “jack-of-all-trades” type of engineer, who without much induction training is capable of performing multiple tasks and of flexibly taking on various roles and functions in the company, which often entail trouble-shooting rather than systematic product and process optimization (the “plug-and-play” engineer).

In particular, start-up companies, whether in the high-tech or in traditional sectors, are commonly characterized by combination of engineering, management and business...
concerns. They therefore, require engineers who combine solid technical knowledge with entrepreneurial, leadership, and technology marketing skills. This combination is rare among engineers of the present.

The experience of leading US high-tech companies shows that it is significantly easier to equip engineers with additional management knowledge, than equip MBAs with the requisite technical knowledge. Both routes have been taken by US universities, e.g. Harvard Business School and UC Berkeley.

For high-tech companies like Xerox and Motorola, a core challenge consists in bringing together new technological knowledge with knowledge about emerging new market opportunities. State-of-the-art technical capabilities are, therefore, a necessary, but not a sufficient pre-requisite for successful innovation.

Xerox made a distinction between Innovation and Science & Engineering, and indicated the following list of things that their engineers lacked a knowledge of:

- End to end view of value
- Customer focused product development
- Systems architecture and engineering
- Design of work processes
- Global markets and extended enterprises
- Technology readiness and section
- Management of risk & uncertainty
- Optimization & decision processes
- Complex program management

With the establishment of global corporate R&D networks, the work setting of R&D engineers has undergone significant changes. Modern IT infrastructure facilitates R&D cooperation and collaboration across continents and time zones, bringing down development times.

Modern engineering work is characterized by the dissolution of functional divisions, in favor of projects and project teams, in which personnel from various areas
(purchasing, R&D, manufacturing, marketing and sales) cooperate and share the responsibility for the entire process, from the initial customer quote all the way to the delivery of the final product.

Technological progress “has induced a blurring and gradual disappearance of traditional disciplinary demarcations of engineers’ activity domains, in favour of new competence definitions and inter-disciplinary task profiles. Increasingly, engineers are required to possess additional skills that previously belonged to the domains of other technical disciplines, and effectively cooperate in multi-disciplinary teams with experts from other technical specializations”. This is happening not only in high-tech sectors but also, for example, in today’s automotive supplier industry, wherein industry project teams for the development of even relatively simple components include specialists from such diverse disciplines as mechanics, electronics, new materials, mathematics, physics and software design.

10. CHANGING KNOWLEDGE AND SKILL DEMANDS ON ENGINEERS [1]

It is increasingly becoming clear that the traditional skill and career profiles of engineers do not apply any more in modern corporate settings. “Today’s engineers require more comprehensive competencies and capabilities transcending mere technical expertise and know-how”.

The Carnegie-Bosch Institute has, in the context of ‘Redesigning Engineers’ Skill Profiles and Career Patterns’, listed the following conclusions for Engineers:

- Less reaction time to adapt to changes
- Managerial skills required early in career
- Continuous skill development required
  - technical skills
  - business skills
  - interpersonal skills
- Global products require global mindset

Nortel Dasa came up with the following list of “If we had 3 wishes.........” :
1. Promote public image of the engineering profession
2. Promote international student exchange programs
3. Teach soft skills
   ✤ teamwork
   ✤ conflict resolution
   ✤ personal behavior
   ✤ leadership
   ✤ media competence
   ✤ time management

Industry, on both sides of the Atlantic, agree that today’s engineers need:
   ✤ a global mindset
   ✤ managerial and leadership skills
   ✤ behavioral competencies, such as good communication skills
   ✤ ability to work in teams; and
   ✤ the capability to cope with rapid change.

“Tomorrow’s engineer” must ‘unite many talents’. These talents include:
   ✤ solid technical foundation skills
   ✤ knowledge from neighboring disciplines
   ✤ a good command of methods
   ✤ non-technical knowledge, such as
     ✤ project management
     ✤ marketing and finance
     ✤ foreign language proficiency
     ✤ understanding of other cultures
   ✤ ability to perform in frequently changing multi-cultural project contexts.
“A high level of engineering competence is crucially important in a global society. Yet, competence has a new definition these days. While knowledge of facts stood in the foreground in the past, today’s needs centre on competence in methods and solutions. Facts are something you access in world-wide databases”.

The discussions at the two trans-Atlantic conferences showed that the catalogue of skills and behavioral orientations required of the “New Engineer” to differ neither between the US and European companies, nor between high-tech and low/medium tech sectors. This seems to reflect the fact that all companies, on either side of the Atlantic, are facing similar competitive challenges in the global economy. The desired skill profiles of engineers described by the corporate speakers were largely congruent with those identified in a series of company surveys carried out by US business and education experts in the run-up to the formulation of the new ABET accreditation standards “Engineering Criteria 2000”. These surveys revealed that most US companies were essentially satisfied with the technical competencies of new engineering graduates. Deficits were observed in the area of ‘soft skills’ and in those ‘hard skills’ domains that lie beyond the curricula of mere discipline-bound technical skills.

Eleanor Baum, (the then) President of ABET, pointed out that industry was very satisfied with the technical skills of the engineers who were being graduated, but they did not have sufficient team skills. “They were very good, in the process of the way we educate them, in taking an exam by themselves. The whole system is set up that way, in working a problem alone. But yet in industry, engineering is a team endeavor, and skills of working in a team environment are things that are not easy to acquire, and engineering schools were doing very little in this regard”. She also stressed the importance of understanding and appreciation of diversity. “Creativity comes from very disparate groups of people working together”.

“The other message we heard from industry was that, while students get a terrific education in individual courses, what was lacking very often was an understanding of how things fit together. We find that faculties teach in very discrete boxes, but the connections to other things in the curriculum were not being made”. “The integration of knowledge is something that industry asked us to work on. A multi-disciplinary perspective is certainly important because there is no such thing as an electrical
engineer spending his or her career working with no one but other electrical engineers who speak the same jargon and understand the same acronyms. They are now working with other people, not only in other engineering and science disciplines, but as part of the teams with whom they are working, there will be non-engineers”.

11. **THE NATURE AND SCOPE OF GLOBAL CHANGES [1]**

Hans-Jorg Bullinger, at the trans-Atlantic Conference, characterized global change as an expression of:

- changes in **product mixes**, which are increasingly dependent on customer preferences.
- changes in **markets**, which are, in much the same way as products, increasingly segmented to conform to customer preferences; customers occasionally become co-producers.
- changes in the **production process**, which are focussed on specific demands as articulated by customers, and characterized by shorter product and production cycles.
- changes in **locations**, since production follows markets.

These changes take place in corporate settings that are characterized by a new world-wide division of labor, by higher productivity demands in industrial production, and by the growing importance of services, and their interaction with new product mixes.

11.1 **Implications for Engineering Education**

In the new global corporate settings, engineers are part of a learning organization, whose building blocks are:

- intelligent products and services
- cooperation techniques
- virtual corporate structures; and
- collaborative learning and work environments.
Rapidly changing demands on companies transform all learning content into a 'moving target'. It is pointed out that Engineering Education must be re-focused to convert the engineer from a ‘technical doer’ into an ‘active creator’ in the man-machine-market environment. This transformation from doer to creator spells the new demands on engineering education.

12. THE CHALLENGES AND RESPONSES IN HIGHER EDUCATION [1]

Table VIII indicates the challenges and responses in higher education.

13. THE SHORTCOMINGS OF CURRENT CURRICULA AND SUGGESTIONS FOR REFORM [1]

Table IX describes the shortcomings of current curricula and some suggestions for reform.

14. LEARNING BY EXPERIMENTING IN UNIVERSITIES [1]

Universities are increasingly recognizing the importance of Learning by Experimenting – within universities, from one department to another; among the universities in a national system; and across national systems. Finland, for example, has said to its institutions: we want each of you to be different; we want each of you to experiment; after 2 or 3 years we will find out what is right or wrong about your experiment.

In order to achieve learning by experimenting, universities must have more freedom and autonomy. This will give them the opportunity to experiment with various reform models that take into account local conditions and individual schools’ strengths.

The same approach of “learning through experimentation” appears to be the guiding principle underlying the new “Engineering Criteria 2000” in the US. The centrepiece of the new ABET accreditation criteria, which were finally adopted in December 1997 after several years of open debate between companies, industry and professional societies, consists of a catalogue of objectives for engineering programs that incorporate many of the new skills demanded by industry. How these goals or objectives are reached is largely left to the discretion of individual schools. The
novelty of EC 2000 as compared to the earlier ABET accreditation standards, is to be seen above all in the focus on results or outcomes instead of processes (and inputs).

15. STRATEGIC RELATIONSHIPS AND EQUATIONS FOR THE EDUCATION AND TRAINING OF AN EFFECTIVE ENGINEER

It is increasingly being recognized that a 4 or 5 year degree does not give a license to practise engineering professions for a lifetime; nor can the University alone provide all the necessary inputs. Strategic relationships and combinations must be established between:

✦ industry and university
✦ initial and continuing education
✦ self-learning and mentored learning
✦ individual learning and group learning (team work)
✦ hard skills and soft skills
✦ multimedia

In sum, engineering education is a multi-partner, multi-mode, multi-disciplinary, multi-media, multi-setting and multi-module enterprise.

16. SUCCESS FACTORS FOR FUTURE-ORIENTED ENGINEERING EDUCATION [1]

The trans-Atlantic conferences have come up with a list of “success factors” as indicators whether a university, department or a degree program in engineering has future prospects, and whether the reform of engineering education was progressive and successful:

✦ adaptability and versatility
✦ innovative drive
✦ speed
✦ selection
✦ motivation
capacity for cooperation

costs

legal framework

17. THE SPECIAL NEEDS OF HIGH-TECH COMPANIES [1]

The high-tech industry is driven by engineers turned entrepreneurs. The success of high-tech start-up companies depends on:

- cutting-edge technical competencies
- technology marketing capabilities
- early high-tech (large cap) customers
- setting standards
- international management
- acting globally
- availability of venture capital

18. INTERNATIONAL COMPARISONS

National education systems and ‘engineering cultures’ differ in their emphasis on:

- technical understanding and analytical skills
- management capabilities
- team work orientation
- ability to accommodate and adjust to rapid technological and organizational change.

It was felt at the trans-Atlantic conferences that in English-speaking countries, the engineering professions have suffered from relatively low social esteem, quite in contrast to Germany. American engineers seemed to have the ability to accommodate rapid change, which has helped U.S. companies to become leaders in many high-tech industries [1].
Table X describes a comparison of the US and Germany in terms of the attractiveness of each destination for graduate study.

19. CONCLUDING REMARKS

There are so many intersections between the spheres of activity and raison d’etre of Industry and University that a structured relationship between the two entities is not only desirable, but also essential. They need each other – the relationship is symbiotic. There is a lot to be gained through the relationship – it is synergistic. Industry-University interaction must be deemed a mainstream activity by both partners.

BIGLIOGRAPHY
